PROGRAM PLAN FOR THE PERFORMANCE TESTING OF PWR SAFETY AND RELIEF VALVES

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SUMMARY

A program plan is presented to evaluate the safety and design characteristics of pressurized water reactor safety and relief valves. This program is responsive to NUREG 0578, Section 2.1.2 "Performance Testing for BWR and PWR Safety and Relief Valves", and is focused on the key issues associated with PWR Safety and Relief Valve system performance. A comprehensive experimental and analytical program is outlined which will evaluate valve operability and provide sufficient data to confirm methods for predicting safety and relief valve discharge piping loads. The experimental program includes full-scale tests of actual PWR relief and safety valves. Available data and experience from foreign relief valve test programs will be utilized to minimize potential delays in the experimental program.

I. INTRODUCTION

A. Purpose and Background

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

Under all normal operating conditions and the majority of postulated transients, the OPPS, if actuated, will pass high quality steam (after loop seal discharge, if present). It may be possible that certain postulated system transients can result in two phase and/or liquid flow through relief and safety valves.

The U.S. Nuclear Regulatory Commission (NRC) in their report NUREG-0578, "TMI-2 Lessons Learned Task Force Status Report and Short-Term Recommendations", dated July 1979, recommends that utilities operating and constructing nuclear power plants develop a program for performance tests of self-actuated safety valves and power operated relief valves which are used in nuclear overpressure protection systems.

A subsequent letter to utilities required implementation of this recommendation for performance tests of safety and relief valves and further required this testing to be complete by July, 1981.

At the request of utilities with PWR's, EPRI developed a PWR Safety and Relief Valve Test Program as defined in "Program Plan for the Performance Verification of PWR Safety/Relief Valves and Systems", December 13, 1979, which was submitted to the NRC on December 17, 1979 in response to NUREG 0578, Section 2.1.2.

This document is a revision of the above referenced Program Plan and provides a more detailed and thorough description of the test program and accompanying analytical projects.

The valve test program described herein is intended to be responsive to the recommendation of the TMI-2 Lessons

Learned Task Force. The primary objective of these tests is to evaluate the performance of each of the various types of reactor coolant system safety and relief valves in pressurized water reactor plant service for the range of fluid conditions under which they may be required to operate.* The requirements are that:

1. The safety and relief valves open and close on command, when subjected to simulated plant operational conditions, calculated to result in valve actuation.
2. The flow capacity of the valves be established.

The second objective of the program is to obtain sufficient piping thermal hydraulic and support reaction load data to permit confirmation of analytical models utilized for plant unique analysis of safety and relief valve discharge piping systems.

B. Contents of the Program Plan

The contents of the following sections of the program plan are as follows:

° Section II -- Technical Approach of Program

This section provides a discussion of the technical approach followed by EPRI in developing the PWR Safety and Relief Valve test program.

* These conditions will be defined based on an evaluation of the transients specified in Regulatory Guide 1.70, Revision 2

- Section III -- Safety and Relief Valves and Configurations

  This section provides a summary of the various safety and relief valves and generic inlet and discharge piping configurations utilized in PWR plant service. Also provided is a listing of the specific valves and piping configurations selected for inclusion in the test program.

- Section IV -- System Conditions which Result in Valve Actuation

  This section provides a summary of the PWR system transients which are calculated to result in valve actuation and the fluid conditions at the inlet to the valves for these transients.

- Section V -- Program for Evaluation of Safety and Relief Valve Performance

  This section discusses the program to be used to evaluate the performance of the safety and relief valves. Included is a discussion of the tests to be performed and the test facilities to be utilized to perform the valve test program by July, 1981.

- Section VI -- Program for Evaluation of Discharge Piping Analytical Methods

  This section describes the program to be followed to produce information (both analytical and experimental) that can be used to evaluate the adequacy of analytical methods for the safety and relief valve discharge piping.

- Section VII -- Appendices

  Appendix A provides the preliminary workscope for relief valve tests to be performed at the Marshall Steam Station facility.

  Appendix B provides the preliminary workscope for the relief valve tests to be performed at the Wyle facility.

  Appendix C provides the preliminary workscope for the safety and relief valve tests to be performed at the Combustion Engineering facility.

  Appendix D provides a summary of valve test programs planned or underway in various foreign test facilities.

II. TECHNICAL APPROACH OF PROGRAM

The program plan to be followed in evaluating the performance of PWR safety and relief valves includes a number of elements which are described in the following:

- A test program will be performed in which selected, actual safety and relief valves are tested under fluid conditions which are calculated to occur during anticipated operational transients and postulated accident sequences in PWR plants. These fluid conditions include steam, water and transition from steam to water. The primary purpose of these tests is to demonstrate that the valves will open and close as required when subjected to simulated transient conditions and that the flow capacity of the valves can be correctly predicted. This program, which will utilize multiple test facilities, is described in Section V of this program plan. It is expected that all testing will be complete by July, 1981.

- A combined test and analysis program will be performed to evaluate the adequacy of analytical methods utilized for PWR safety and relief valve discharge piping response. First, the main valve test facility at Combustion Engineering will include prototypical upstream piping, including water seals, and a simplified discharge piping arrangement which simulates significant features of plant discharge piping systems. These systems will be instrumented to measure dynamic loads, piping response and fluid conditions. In parallel with this effort, engineering evaluations are being performed to assess the adequacy of available methods for prediction of safety and relief valve discharge piping loads. A key part of this effort is the analysis of a number of sample problems using state-of-the-art methods. These problems will include the upstream and discharge piping configurations and ranges of fluid conditions selected for use in the valve performance tests. In addition, analysis of piping configurations representative of actual PWR discharge piping installations has been initiated to demonstrate that the test configuration adequately represents all significant features important to safety and relief valve operation. The combined results of these analytical and test programs will provide the data needed to confirm the analytical methods used for piping and support analysis. This information will then be available to utilities for use on a plant-specific basis for evaluation of installed discharge piping systems. This program is described in Section VI of the program plan.

- An evaluation will be performed of available data and experience obtained in foreign valve test facilities, and any domestic test programs that may be applicable. Utilization of other related test experience is considered desirable in order to identify and minimize potential problem areas which might otherwise have an impact on the EPRI test program schedule. The foreign test programs are described in Appendix D of the program plan.

- Effort is underway to evaluate the effects of postulated valve failure modes (e.g., excessive leakage, excessive blowdown, reduced flow capacity, etc.,) on reactor system performance in order to establish preliminary acceptance criteria and guidelines for evaluation of the significance of the valve test results.

- Evaluations of the Crystal River 3 safety and relief valves and piping will be performed. This will be a co-operative effort among EPRI, Florida Power Corporation and Babcock and Wilcox to examine the valves and piping at Crystal River 3 which were subjected to water discharge conditions in February 1980. This evaluation is expected to provide early information on the performance of the affected valves and discharge piping. It may also provide useful information on the effect of service history and aging on valve performance.

III. SAFETY AND RELIEF VALVES AND CONFIGURATIONS

1. Valve Types

The numbers, sizes and types of spring-loaded safety valves, pilot-actuated safety valves, and power-operated relief valves (PORVs) in use and planned for primary system overpressure protection in domestic PWRs are summarized herein. In the discussions which follow the types of valves used for overpressure protection in PWRs are listed. These include:

- Safety valves - safety valves are valves which are recognized and required by the ASME Boiler and Pressure Vessel Code, Section III, for overpressure protection. They may be spring-loaded or pilot-actuated, but both types are self-actuated at a pre-selected set pressure by the fluid pressure in the protected system. They do not depend upon an external power supply or control system to operate to provide protection against overpressure.

- Power-operated relief valves - power operated relief valves, referred to herein as relief valves or PORVs, are valves which require an external power supply (normally air and/or electrical) for actuation and are typically controlled by an electrical control signal resulting from high system pressure or manual actuation from the control room.

The types, models and numbers of safety and relief valves used in PWR's are summarized in Tables III-1 through III-4. These tables provide the following information:

- Table III-1 provides a listing of the types of safety valves (identified by manufacturer and model number) and the PWR plant units which utilize these valves.

- Table III-2 provides a listing of the types of relief valves (identified by manufacturer and model number) and the PWR plant units which utilize these valves.

- Table III-3 provides a summary of the population of safety valves in PWR plant service.

- Table III-4 provides a summary of the population of relief valves in PWR plant service.

As can be seen from the above tables, a large number of safety and relief valve models are used in PWR plants. As a result, it is necessary that engineering judgment be exercised in selecting a number of valve types, models and sizes for test purposes that will provide meaningful generic results that are applicable to all of the plants involved. It is also necessary to select generic test configurations in order to assure that results are obtained by July, 1981.

The approach used in selecting the test valves is based on the following criteria:

1. Each basic valve type should be represented.

2. Each different manufacturers' version of a given valve type should be represented except when very limited numbers of such valves are in use and the valve operational mechanisms are similar to other valves being tested.

Based on these criteria, the safety and relief valves listed in Table III-5 were selected for testing. Engineering evaluations will be performed by the individual valve manufacturers, under EPRI contract, to show that the results of testing of the selected valves can be extended to (1) other sizes of the same basic valve type, and (2) different valve models of the same valve type which may have minor differences in detailed design features.

B. Piping Configuration

Upstream and downstream piping configurations differ from plant to plant. In some cases safety valves are mounted directly on the top of the pressurizer with a short, vertical inlet pipe. In other cases water seal arrangements which trap condensed water are used. PORV's include upstream isolation, or block valves and may be mounted on the pressurizer or in an adjacent compartment. Downstream piping configurations are unique to each plant in both size and arrangement, but all are directed to a pressure relief tank. As a result, valves may be subjected to a wide range of backpressures when discharging.

In view of the diversity in upstream and downstream piping arrangements, it was concluded that different upstream and downstream piping configurations should be tested only as needed to properly model their effects on valve operability and to provide sufficient data to verify analytical methods for discharge piping response. Specifically, upstream piping configurations utilized in the test program include those representing essentially the (1) minimum and maximum upstream pressure drop (i.e., shortest and longest piping runs), and (2) configurations which can trap condensate as well as those which cannot (i.e., water seal arrangements and short vertical inlet pipes). The reason for representing the extremes of upstream piping configurations in service is that upstream pressure drop and the presence of saturated (or subcooled) water could have significant effects on valve performance (e.g., response and stability). Downstream piping configurations are modeled to the extent necessary to simulate their main effect on the function of safety and relief valves; namely, the effect of different backpressures. In addition, the downstream piping configurations include several straight lengths of piping and elbows typical of actual plant installations. The test plan requires that the test valves and piping be suitably instrumented to provide data on reaction forces and piping response during the various test conditions.

Based on these criteria, the following upstream and downstream piping configurations were selected for testing.

1. <u>Upstream Piping Configurations for Safety Valves</u>

   a. Short vertical inlet pipe

   b. Typical water seal arrangement (eight to 12 feet of piping)

2. <u>Upstream Piping Configurations for PORV's</u>

   a. Short vertical inlet pipe with block* valve.

   b. Approximately 35 feet of inlet piping with at least two elbows, a block valve and a vertical drop (valve lower than steam supply header) to permit condensate accumulation.

3. <u>Downstream Piping Configurations</u>

   Sufficient downstream piping to permit flow measurement and backpressure control by means of control valves or orifices. The discharge piping at the primary test facility (CE) will include several elbows and piping runs typical of those used in PWR plants and extensive instrumentation to obtain data for model confirmation.

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* Performance tests of block valves is not a part of the PWR Safety and Relief Valve Test Program. It is anticipated that some limited performance data on specific block valves may be obtained, consistent with the overall program test schedule.

TABLE III-1 SAFETY VALVES IN PWR PLANTS

SAFETY VALVES

MANUFACTURER	MODEL	UNITS	
Crosby Valve & Gauge	HB-BP-86 Series	Farley -1&2	ANO -2
		Robinson -2	Harris -1,2,3,&4
		Zion -1&2	Byron -1&2
		Braidwood -1&2	Conn Yankee
		Indian Point -2&3	Mc Guire 1&2
		Beaver Valley-2	Turkey Point -3&4
		St. Lucie -1&2	Vogtle -1&2
		Cook -1&2	Wolf Creek
		Jamesport 1&2	Millstone -3
		Prarie Island 1&2	Ginna
		Ft. Calhoun -1	Diablo Canyon -1&2
		Trojan	Marble Hill -1&2
		Seabrook 1&2	Salem -1&2
		Summer	San Onofre -1
		South Texas -1&2	Sequoyah -1&2
		Watts Bar -1&2	Yellow Creek -1&2
		Comanche Peak -1&2	Davis Besse -1
		Callaway -1&2	North Anna -3&4
		Point Beach -1&2	WNP-3+5 Kewaunee
Dresser Industries	1719 WA 31709 A 31709 NA	Yankee Rowe	
		Maine Yankee	
		Palo Verde -1, 2, & 3	
		Pilgrim -2	
		Palisades	
		Perkins -1,2, & 3	
		Cherokee -1,2, &3	
		Pebble Springs -1&2	
		San Onofre -2&3	
		Bellefonte -1&2	
		WNP -1&4	

TABLE III-1 (Continued)

SAFETY VALVES (Cont)

MANUFACTURER	MODELS	UNITS
Dresser Industries	31739 A	Calvert Cliffs -1&2 Midland -1&2 Oconee -1,2, & 3 Crystal River -3 Three Mile Island -1 Millstone -2
	31749 A	Catawba -1&2 Waterford -3
	31759 A	Ano -1 Three Mile Island -2 Rancho Seco
Target Rock	69C	Beaver Valley -1

TABLE III-2 RELIEF VALVES IN PWR PLANTS

RELIEF VALVES

MANUFACTURER	MODEL	UNITS
Black, Sivalls	70-18-9 DRTX	San Onofre -1
Control Components International	3" DRAG	Mc Guire -1&2 Catawba -1&2
Copes Vulcan	3" -1500 Series	Farley -1&2 Robinson -2 Harris -1,2,3,&4 Zion -1&2 Byron -1&2 Braidwood -1&2 Conn. Yankee Indian Point -2&3 Turkey Point -3&4 Jamesport -1&2 Millstone -3 Prairie Island -1&2 Trojan Marble Hill -1&2 Seabrook -1&2 Salem -1&2 Ginna Summer South Texas -1&2 Comanche Peak -1&2 Point Beach -1&2
Crosby Valve & Gauge	HPV-SM	Davis Besse -1 North Anna -3&4

TABLE III-2 (Continued)

RELIEF VALVES

MANUFACTURER	MODELS	UNITS
Dresser Industries	31533Vx Series	ANO -1 Calvert Cliffs -1&2 Pilgrim -2 Palisades Midland -1&2 Oconee -1,2,&3 Crystal River 3 Maine Yankee Three Mile Island -1&2 Millstone -2 Ft. Calhoun -1 Pebble Springs -1&2 Rancho Seco Bellefonte -1&2 WNP -1&4 Yankee Rowe
Fisher Controls	SS-103-SS-95	Beaver Valley -2 Vogtle -1&2 Watts Bar -1&2
Masoneilan International	20000 Series	Beaver Valley -1 Cook -1&2 Diablo Canyon -1&2 Sequoyah -1&2 North Anna -1&2 Kewaunee

TABLE III-3 POPULATION OF PWR SAFETY VALVES

MANUFACTURER	MODEL	POPULATION UNITS/VALVES	PERCENT
Crosby Valve & Gauge	HB-BP-86 Series	67/189	71
Dresser Industries	31700 Series	36/72	27
	1719 WA	1/2	1
Target Rock	69C	1/3	1
	TOTAL	105/266	100

TABLE III-4 POPULATION OF PWR RELIEF VALVES

MANUFACTURER	MODEL	POPULATION* UNITS/VALVES	PERCENT
Black, Sivalls	70-18-9CRTX	1/2	1
Control Components International	3" Drag Type	4/8	6
Copes Vulcan	3"-1500 SERIES	38/76	53
Crosby Valve & Gauge	HPV-SN	3/3	2
Dresser Industries	31533VX SERIES	24/24	17
Fisher Controls	SS-103-SS-95	5/10	7
Masoneilan Int.	20000 SERIES	10/20	14
	TOTALS	85/143	100

*Assume 1 PORV for each B&W and CE unit (except CE units w/o PORVs) and 2 PORVs for each W unit.

TABLE III-5 RELIEF AND SAFETY VALVES SELECTED FOR TESTING

VALVE TYPE	MANUFACTURER	MODEL DESIGNATED	SELECTED FOR TEST
1. Safety Valve (Spring, Balanced)	Crosby	HB-BP-XX Type	HB-BP-86 (6M6)
2. Safety Valve (Spring, Balanced)	Dresser	31700 Series	31739 A 31709 NA
3. Safety Valve (Pilot Operated)	Target Rock	69C	69C
4. Relief Valve (Pressurmatic)	Crosby	HPV-SN	HPV-SN
5. Relief Valve (Electromatic)	Dresser	31533VX Type	31533VX-30
6. Relief Valves (Air Operated)	Control Components Copes Vulcan Fisher Controls Masoneilan	3" Drag 3"-1500 Type SS-103-SS-95 Type 20000 Series	3" Drag 3"-1500 SS-103-SS-95 (Later)

IV. SYSTEM CONDITIONS WHICH RESULT IN VALVE ACTUATION

The objective of the safety and relief valve test program is to evaluate the performance of a representative number of actual relief and safety valves under fluid discharge conditions calculated to occur during operational transients and postulated accidents.

A. PWR System Transients

The final determination of relief and safety valve test conditions will be based on an evaluation of the event types specified in Regulatory Guide 1.70, Revision 2. The following is an evaluation of these events and the resulting fluid conditions at the inlet to the safety and relief valves.

In PWR plants, there are three classes of transients for which the pressurizer safety and/or relief valves may be actuated. These are:

- The typical SAR transients, such as loss of normal feedwater, loss of external electrical load and/or turbine trip, uncontrolled rod withdrawal, feedwater piping break, etc.

- Cold pressurization transients resulting from coolant make-up/letdown mismatch, reactor coolant pump start, inadvertent safety injection, etc.

- Transients resulting in actuation of the high pressure injection system where injection is not terminated prior to repressurization to relief or safety valve set pressures.

A list of transients calculated to result in valve actuation is given in Table IV-1. This preliminary information is based on discussions with NSSS personnel, review of existing safety analyses and topical reports, and review of problems or maloperations of valves in service.

B. Fluid Conditions at the Valve Inlet

For the transients identified in Table IV-1, envelopes of expected fluid conditions have been identified for safety valves and relief valves based on information provided by the NSSS suppliers, as given in Tables IV-2 and IV-3. The bases for these conditions are discussed in the following:

1. SAR-Type Plant Transients

   - Pressure Range

     For the SAR-type transients, the maximum transient pressure ranges from just above the set pressure to approximately 2750 psia for the more severe transients.

- Pressurization Rate

  The pressurization rate ranges from 15 to 300 psi/sec for the SAR-type transients. However, for most of the transients, the pressurization rate is about 50 psi/sec.

- Fluid Conditions

  For most of the SAR-type transients, the safety and relief valves open with saturated steam at the valve inlet, and the flow through the valves during the transient is saturated steam. However, some combinations of feedwater line break locations and system assumptions may result in filling of the pressurizer with liquid and discharge of liquid through the safety or relief valves during pos trip recovery. This can result from either swell of primary fluid due to heat-up or injection of additional fluid by the safety injection or normal make-up system. For these transients, the valves could open on steam and experience a transition from steam to subcooled water flow, or they could open on subcooled water. Water temperatures could vary from 450 to 650°F.

2. Cold Pressurization Transients

- Pressure Range

  For the cold pressurization transients, the maximum transient pressure varies from just above the valve set pressure* (for cases where a steam or nitrogen bubble is maintained in the pressurizer) to about 200 psi above the set pressure (for cases with a solid system).

- Pressurization Rate

  The pressurization rate varies from less than 5 psi/sec (cases with a steam or nitrogen bubble in the system) to 200 psi/sec (cases with a solid system).

- Fluid Conditions

  For the cases where a steam or nitrogen bubble is maintained in the system, the valves open on steam (or steam/nitrogen mixture) and the flow through the valves is steam (or steam/nitrogen mixture). For the cases where the system is solid, below 300°F, the relief valves open on subcooled water and the flow through the valve is subcooled water.

* For cold pressurization transients in actual plant operation, the PORV set points are reduced to approximately 500-700 psia.

3. <u>Extended Operation of High Pressure Injection System</u>*

- <u>Pressure Range</u>

  The maximum transient pressure ranges from the valve set pressure to just above 2500 psia.

- <u>Pressurization Rate</u>

  The pressurization rate would be less than 20 psi/sec.

- <u>Fluid Conditions</u>

  For these transients, the valves could open on steam and experience a transition from steam to subcooled water flow, or they could open on subcooled water. Water temperatures could range from 450 to 650°F.

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* In most cases the extended operation of high pressure injection would be a consequence initiated by an SAR-type transient.

TABLE IV-1 PWR TRANSIENTS WHICH MAY RESULT IN SAFETY OR RELIEF VALVE ACTUATION

Plant Transient
Loss of external electrical load and/or turbine trip
Loss of normal feedwater
Uncontrolled rod withdrawal
Loss of all AC power
Main feedwater pipe rupture
Seizure of reactor coolant pump rotor
Cold pressurization transients
Extended operation of high pressure injection system*

* Only in those plants where the system is capable of injection at valve set pressures (2400-2500 psia).

TABLE IV-2 PWR SAFETY VALVE FLUID CONDITIONS

Class of Transient	Pressure Range (psia)	Pressurization Rate (psi/sec)	Fluid Conditions
SAR-Type Plant Transients	2500[(1)]-2750	15 - 300	Valves open on steam; flow through valves is steam
Extended Operation of High Pressure Injection	About 2500[(1)]	Less than 20	Valves open on steam; flow changes to subcooled water[(2)] or, Valves open on subcooled water; flow is subcooled water[(2)]

NOTES: (1) Assumed valve set pressure

(2) These conditions cover the SAR transients which can result in filling up the pressurizer.

IV-3 PWR RELIEF VALVE FLUID CONDITIONS

Class of Transient	Pressure Range (psia)	Pressurization Rate (psi/sec)	Fluid Conditions
SAR-Type Plant Transients	2400[(1)] - 2750	15 - 300	Valves open on steam; flow through valves is steam
Cold Pressurization Transients	500[(2)] - 700	200	Valves open on subcooled water (120-300°F); flow is subcooled water
	500[(1)]	Less than 5	Valves open on steam or steam/nitrogen mixture; flow is steam or steam/nitrogen mixture
	1015[(1)]	Less than 5	Valves open on steam; flow is steam
Extended Operation of High Pressure Injection	2400(2)	20	Valves open on steam; flow changes to subcooled water or, Valves open on subcooled water; flow is subcooled water

NOTES:

(1) Assumed valve set pressure

(2) These conditions cover the SAR transients which can result in filling of the pressurizer

V. PROGRAM FOR EVALUATION OF SAFETY AND RELIEF VALVE PERFORMANCE

A. Tests to be Performed

Full flow tests of three spring-loaded safety valves, one pilot-actuated safety valve, and six power-operated relief valves will be performed under a wide range of fluid conditions. Each will be a performance test to demonstrate the capability of the valves to operate satisfactorily under steam inlet conditions, as well as a range of subcooled water and transition (steam to water) flows. A number of set pressures, capacities, peak pressures, pressure ramp rates, reseat pressures and back pressures will be covered. As a part of the valve testing, data will also be obtained to determine performance parameters such as valve capacity, and flow reaction forces.

The specified tests are based on the use of a transient blowdown type of test facility which utilizes accumulators charged to an appropriate pressure and temperature to achieve the conditions representative of those expected in service. The duration of the test will be approximately 10 to 30 seconds (depending on the type of test, the valve size and the facility utilized) which will be sufficient to obtain valid performance characteristics and data.

During the course of the specified tests, each valve will be subjected to a umber of operational cycles. However, it should be noted that the test program, to be completed by July, 1981, is not intended to provide valve lifetime, cyclic fatigue or statistical reliability data.

Specific combinations of valve types, piping configurations and test conditions are specified in the test matrix presented in Table V-1. The main elements of the test program are summarized below:

- The valve types to be tested include essentially all of the generic valve types in service (e.g., balanced spring-loaded safety valves, Electromatic or Pressurematic PORV's, air-operated globe valves and self-actuated pilot-operated safety valves) and include models supplied by each of the major suppliers (e.g., Dresser, Crosby and Target Rock). Such a grouping results in ten PWR test valves.

- The numerous piping configurations in service are modeled as follows: The range of inlet piping configurations are covered by two test set-ups for the safety valves - one representing a short, vertical inlet pipe and one representing a water seal arrangement which has a volume of condensed (subcooled) water. The pilot-operated PORVs will be mounted in a vertical configuration and the air-operated PORVs will be mounted in a horizontal configuration. Outlet piping will be included as required to obtain flow and dynamic load measurements and to control back pressure. As discussed in more detail in Section VI of this report, this piping will include piping sizes and runs, with elbows, typical of those used in PWR plants.

- Upstream fluid conditions will include single-phase steam (representing normal design conditions and the majority of postulated plant transients and accidents), single-phase sub-cooled water, and a transition flow test in which the test valve opens and discharges steam followed by a transition to subcooled water flow. These fluid conditions cover those considered to be limiting from a valve operability standpoint.

Test instrumentation will be provided to measure system parameters (valve inlet, accumulator and valve discharge piping parameters), including:

- Inlet and discharge pressure
- Inlet and discharge temperature
- Discharge (back) pressure
- Mass flow rate (measurement of mass flow rate will be made by an upstream venturi and accumulator inventory measurements; instrumented spool pieces to accommodate gamma densitometer, drag disc and turbine are being provided)

Special instrumentation will be provided to measure valve parameters, including:

- Valve stem position (stroke) e.g., linear variable differential transformers, where possible.
- Valve body temperatures.
- Accelerometers for sensing opening and closing of internal pilots and disks and response to fluid reaction loads.
- Valve operator input parameters (air pressure, electrical power, etc.).
- Strain gages or load cell instrumentation for measurement of valve and piping reaction forces.

The parameters listed above will be recorded for each test on a high speed data acquisition system. This system shall include the capability to plot, display and/or print data from selected channels for "quick-look" evaluation after each test. Specific numbers of instruments, their locations, response times, ranges and accuracy requirements will be developed as a part of detailed test procedure preparation. Preliminary lists are provided in the workscope (see Appendices A, B, and C) for the valve test facilities.

B. Test Facilities and Schedules

In order to be responsive to the severe schedular requirements of NUREG-0578, the required PWR safety and relief valve tests have been divided between the Combustion Engineering, Wyle and Marshall (Duke Power Company) facilities. The specific division of testing is shown in Table V-2. Though the Combustion Engineering facility is presently designed and has the capability to perform all the safety and relief valve tests as required in NUREG-0578, test results from both Marshall and Wyle will be used where appropriate to replace those corresponding tests presently identified for Combustion Engineering. The Marshall facility will be used for relief valve tests with steam conditions. The Wyle facility will be used primarily to perform water flow tests with the relief valves, but will also have the capability to perform relief valve steam flow tests. The Marshall and Wyle facilities will be valve test facilities, and will have only a minimum amount of up-stream and downstream piping. The Comubstion Engineering (CE) facility will be utilized to perform those required safety and relief valve tests under steam, water, and steam to water transition flow conditions.

The CE facility will be a combined valve/piping test facility. The valve upstream and downstream piping configuration in the CE facility will be consistent with that shown in Figures VI-1 through VI-4 of this program plan. Preliminary workscopes for the valve testing to be performed in the Marshall, Wyle, and CE facilities are provided in Appendices A, B, and C, respectively.

Summary descriptions of the CE, Wyle and Marshall facilities are provided in the following sections along with the schedules to be followed for the construction and checkout of the facilities and the performance of the valve tests.

- Combustion Engineering Facility

  The Combustion Engineering facility has a design pressure of 3250 psia and the capability to run tests up to a pressure of about 2900 psia. A schematic of the CE facility is provided in Figure V-3. For the tests in the CE facility, the test valves will be mounted either on the top nozzle of the 500 ft^3 accumulator vessel or removed from the accumulator vessel on a ground level test stand. A larger 1100 ft^3 vessel will be utilized as a steam or a water supply for the accumulator vessel.

  A test initiation valve will be utilized between these two vessels to initiate the test. The test will proceed until the pressure decays to the valve reset press e and the valve closes (Figure V-1). The facility will have the capability for performing steam, water and transition (steam to water) tests with a test duration of approximately 10 to 20 seconds with the largest safety valve in service. A current schedule for the completion of test facility construction, facility checkout tests and valve performance tests is provided in Table V-3.

- Wyle Facility

  The Wyle facility has the capability to perform valve tests up to a pressure of about 2700 psia. For the Wyle facility tests, the test valves will be mounted off the bottom nozzle of a 300 ft^3 steam or water accumulator vessel as shown in Figure V-4. For the water flow tests, a 600 ft^3 nitrogen supply vessel will be used to drive the water from the accumulator vessel. The test relief valve will be electrically actuated to initiate the test and the test will continue until the pressure decays to the valve reseat pressure and the valve is closed (Figure V-2). The facility will have the capability of performing steam or water tests of PORV's with a test duration of approximately 10 seconds. A current schedule for the Wyle facility tests is provided in Table V-3.

- Marshall Facility

  The Marshall facility has the capability to perform valve tests up to a pressure of about 2500 psia. In these tests, the valves will be mounted off the steam drum of a high-pressure boiler as shown in Figure V-5.

The boiler has the capacity to provide a steady-state steam flow rate equal to the capacity of the largest relief valve to be tested. The test relief valve will be electrically actuated to initiate the test and the test will continue for approximately 30 seconds until the test valve is closed. A current schedule for the Marshall facility tests is provided in Table V-3.

TABLE V-1

SAFETY AND RELIEF VALVE TEST MATRIX

TEST VALVE	INLET PIPING	FLUID CONDITIONS									REMARKS
		INITIAL ACCUMULATOR CONDITIONS			TRANSIENT CONDITIONS						
		P_0 (PSIA)	T_0 (°F)	FLUIDS	SET OR ACTUATION P (PSIA)	P RAMP RATE (PSI/SEC)	REQUIRED PEAK P (PSIA)	RE-SEAT P (PSIA)	TRANSIENT DESCRIPTION	BACK PRESSURE (PSIA)	
A. Safety Valves (spring-loaded types) • Crosby HB-BP-86 • Dresser 31719A • Dresser 31709NA	1. Straight, vertical inlet, 2-3 feet long) AND 2. Water Seal Arrangement	2400	660	Steam	2500	~200 (1) and ~15 (2)	2600-2650	(3)	Steam Flow, See Figure V-1	100 and 500	15 Tests
		2400	650	Water	2500	~15	(4)	(3)	Water Flow, See Figure V-1 (5), (6)	100 and 500	12 Tests
		2400	550	Water	2500	~15	(4)	(3)	Water Flow, See Figure V-1 (5)	100	6 Tests
		2400	450	Water	2500	~15	(4)	(3)	Water Flow, See Figure V-1 (5)	100	6 Tests
B. Safety Valves (pilot-operated type) • Target Rock 69C	Water Seal Arrangement	2400	660	Steam	2500	~200 (1) and ~15 (2)	2600-2650	(3)	Steam Flow, See Figure V-1	100 and 500	3 Tests
		2400	650	Water	2500	~15	(4)	(3)	Water Flow, See Figure V-1 (5), (6)	100 and 500	2 Tests
		2400	550	Water	2500	~15	(4)	(3)	Water Flow, See Figure V-1 (5)	100	1 Test
		2400	450	Water	2500	~15	(4)	(3)	Water Flow, See Figure V-1 (5)	100	1 Test 46 Tests

NOTE:
(1) Actual ramp rate will depend on the capabilities of the test facility and the capacity of the test valve.
(2) These low pressurization rate tests should be performed for only one inlet piping configuration (Configuration 1 where two are specified) and for the low back pressure condition.
(3) Re-seat pressure will not be directly controlled. Valves will be set to achieve a nominal blowdown of 5% (about 125 psi).
(4) Peak pressure will not be controlled but will depend on the valve characteristics under water flow conditions.
(5) These are fixed-flow tests with a liquid flow rate of approximately 1000 gpm. It is possible that repetitive valve actuations will occur during these tests.
(6) The higher (500 psia) back pressure tests will include an initial steam flow period followed by a transition to subcooled water flow.

TABLE V-1

SAFETY AND RELIEF VALVE TEST MATRIX

TEST VALVE	INLET PIPING	FLUID CONDITIONS									REMARKS
		INITIAL ACCUMULATOR CONDITIONS			TRANSIENT CONDITIONS						
		P_0 (PSIA)	T_0 (^oF)	FLUIDS	SET OR ACTUATION P (PSIA)	P RAMP RATE (PSI/SEC)	REQUIRED PEAK P (PSIA)	RE-SEAT P (PSIA)	TRANSIENT DESCRIPTION	BACK PRESSURE (PSIA)	
C. PORVs (Solenoid Pilot-Operated) • Crosby HPV-SN • Dresser 31533VX-30	Vertical Configuration	2700	680	Steam	2700	(1)	2700	2300	Steam Flow, See Figure V-2	100 and 500	4 Tests
		2700	650	Water	2700	(1)	2700	2300	Water Flow, See Figure V-2(2)	100 and 500	4 Tests
		2700	550	Water	2700	(1)	2700	2300	Water Flow, See Figure V-2(2)	100	2 Tests
		2700	450	Water	2700	(1)	2700	2300	Water Flow, See Figure V-2 (2)	100	2 Tests
		500	467	Steam	500	(1)	500	400	Steam Flow, See Figure V-2	100	2 Tests
D. PORVs (Air-Operated Globe Valve Type) • Control Components 3" Drag	Horizontal Configuration	2700	680	Steam	2700	(1)	2700	2300	Steam Flow, See Figure V-2	100 and 500	8 Tests
		2700	650	Water	2700	(1)	2700	2300	Water Flow, See Figure V-2(2)	100 and 500	8 Tests
• Copes-Vulcan 3" - 1500		2700	550	Water	2700	(1)	2700	2300	Water Flow, See Figure V-2(2)	100	4 Tests
• Fisher Controls SS-101-SS-95		2700	450	Water	2700	(1)	2706	2300	Water Flow, See Figure V-2 (2)	100	4 Tests
• Masoneilan		500	300	Water	500	(1)	500	400	Water Flow, See Figure V-2 (2)	100	4 Tests 42 Tests

TOTAL TESTS 88

NOTE (1) The test will be initiated by electrically actuating the PORV; therefore, the pressure ramp rate will be zero.

(2) These are fixed-flow tests with a liquid flow rate of approximately 1000 gpm.

TABLE V-2

EPRI VALVE TEST PROGRAM
- TEST FACILITY UTILIZATION

TYPE OF TEST	TEST FACILITY
Relief Valves	
- Steam Tests	Combustion Engineering 1/, Marshall 2/
- Water Tests	Combustion Engineering 1/, Wyle 2/ 3/
Safety Valves	
- Steam Tests	Combustion Engineering 4/
- Water Tests	Combustion Engineering 4/

NOTES:

1/ Marshall and Wyle test results will be used where appropriate to replace similar tests at Combustion Engineering.

2/ These are valve test facilities with only minimum discharge piping.

3/ The Wyle facility will also have the capability for performing steam tests.

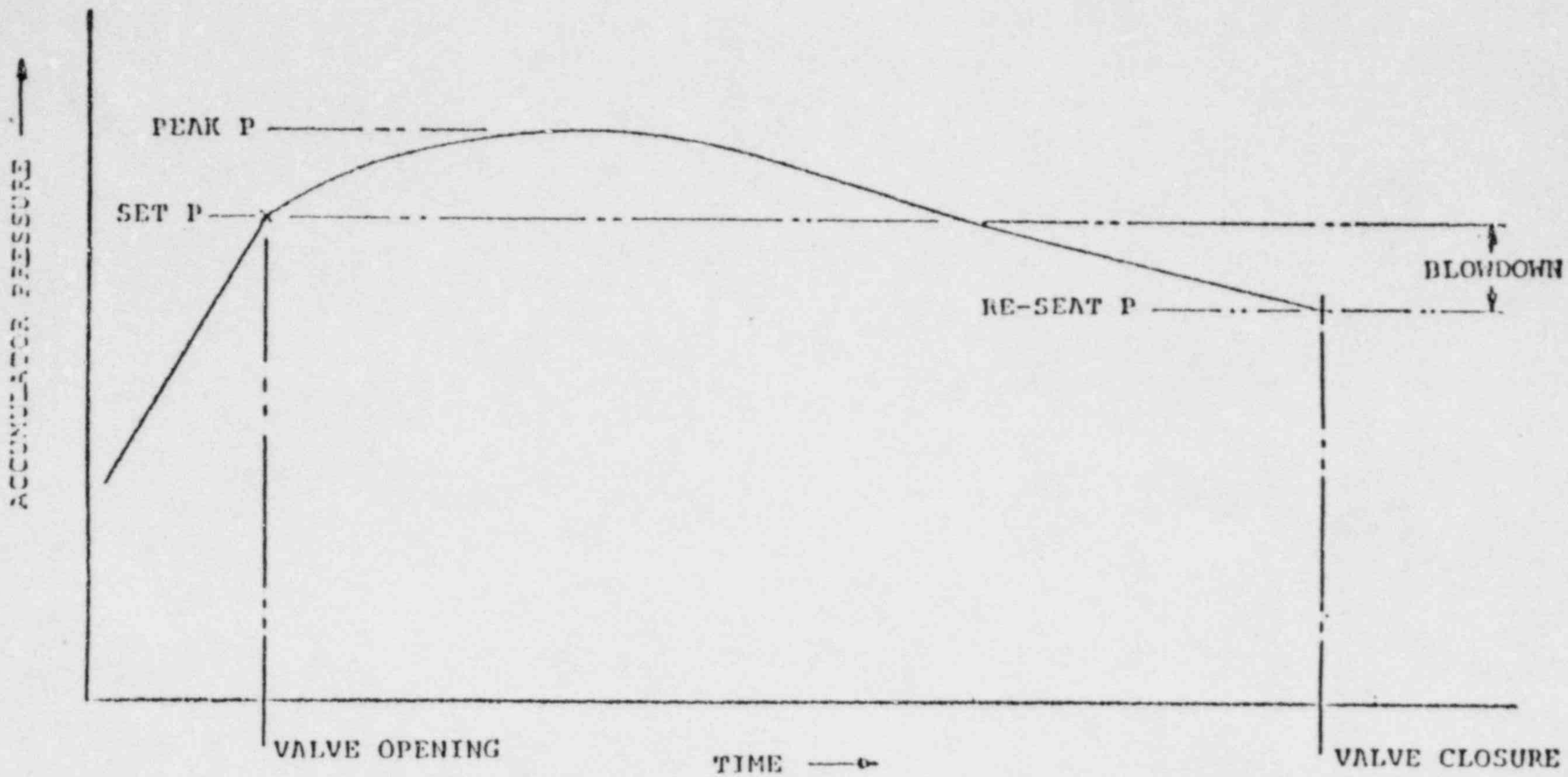
4/ This is a combined valve and piping test facility.

TABLE V-3

VALVE TEST FACILITY SCHEDULES

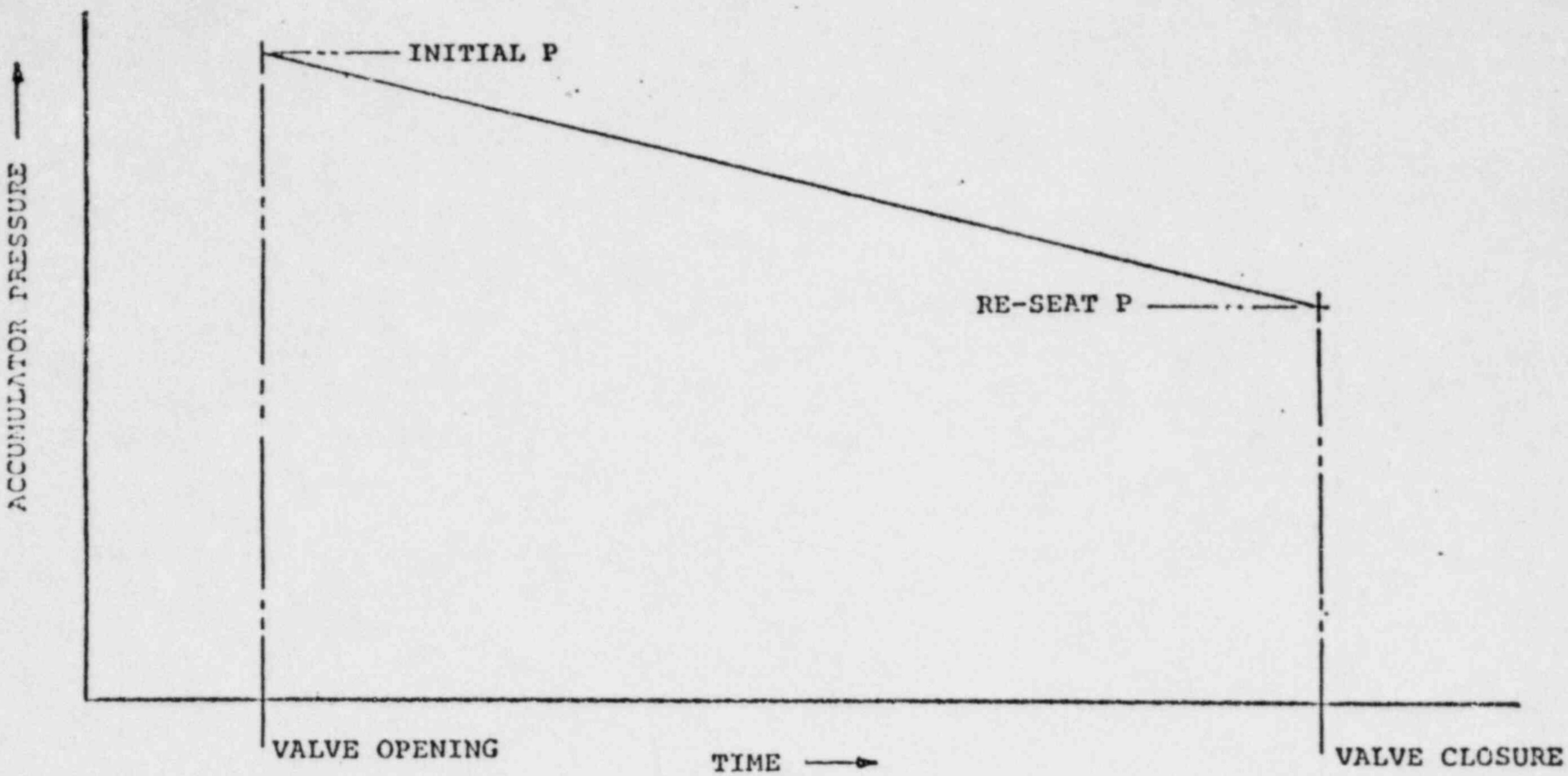
Phase	TEST FACILITY CE	Wyle	Marshall
° Completion of test facility construction	February 1981	October 1980	Completed
° Completion of facility checkout	March 1981	November 1980	June 1980
° Completion of valve testing	July 1981*	January 1981	December 1980

*This scheduled completion date is based on the successful completion of a significant number of relief valve tests to be performed at the Marshall and Wyle Test Facilities.



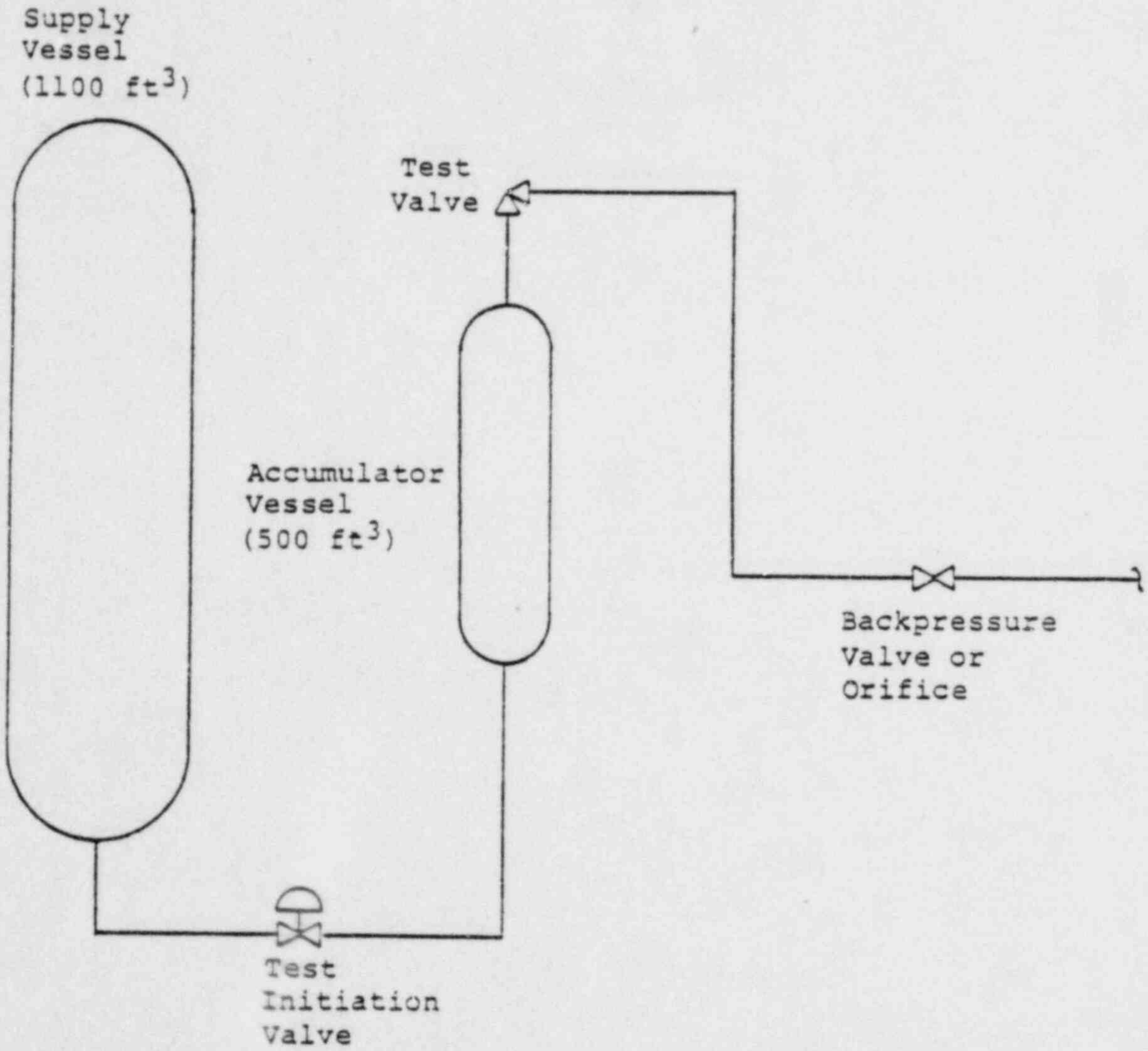
FLUID TRANSIENT CONDITIONS FOR TYPICAL
SAFETY AND RELIEF VALVE (STEAM OR WATER) TESTS
FOR THE CE FACILITY

FIGURE V-1



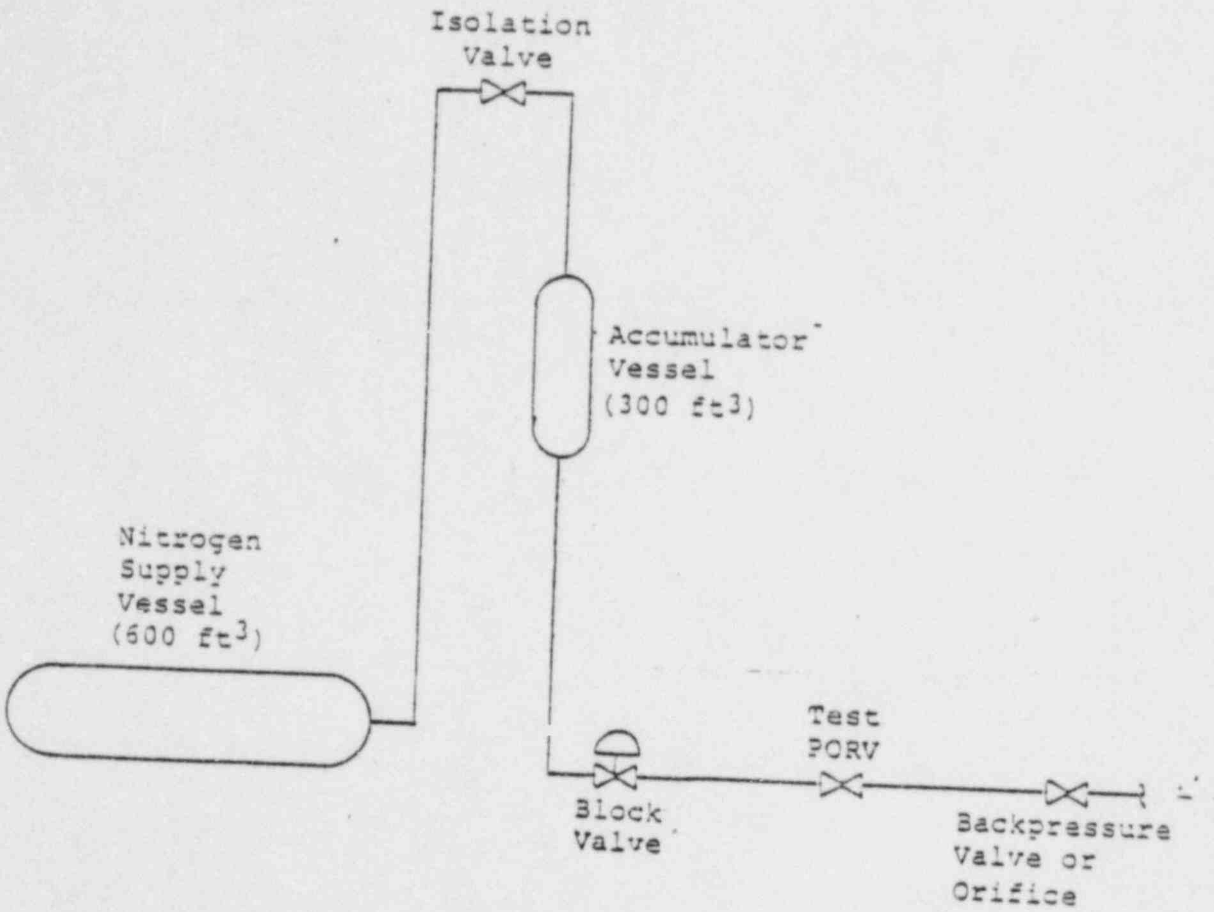
FLUID TRANSIENT CONDITIONS FOR TYPICAL
RELIEF VALVE (WATER OR STEAM) TESTS
AT THE WYLE FACILITY

FIGURE V-2



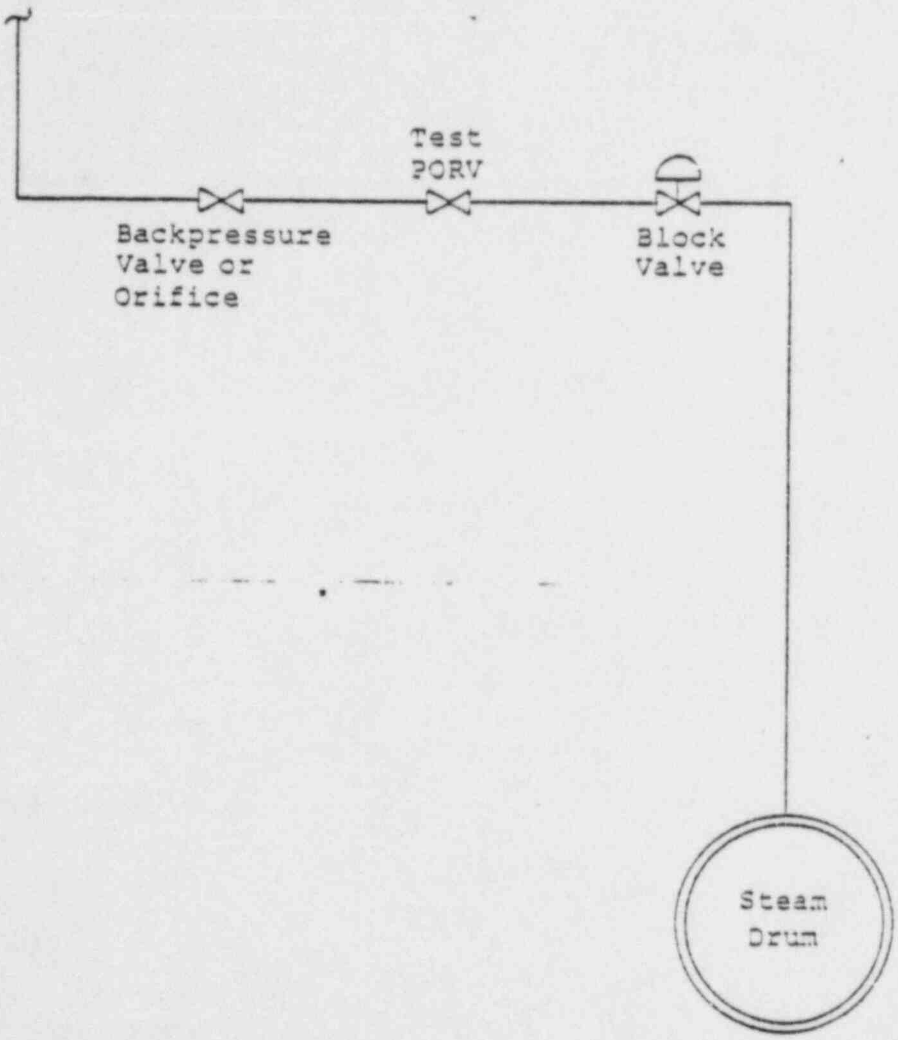
SIMPLIFIED SCHEMATIC
OF
CE FACILITY

FIGURE V-3



SIMPLIFIED SCHEMATIC
OF
WYLE FACILITY

FIGURE V-4



SIMPLIFIED SCHEMATIC
OF
MARSHALL FACILITY

FIGURE V-5

VI. PROGRAM FOR EVALUATION OF DISCHARGE PIPING ANALYTICAL METHODS

The PWR safety and relief valve test program is intended to provide the necessary data and information to evaluate analytical tools for predicting hydrodynamic loads on safety and relief valve discharge piping. The strategy for achieving this objective is outlined below:

1. Inlet Piping

Inlet piping configurations used in PWR safety and relief valve systems vary from plant to plant but can be categorized as either short and self-draining or relatively long and configured such that condensate will fill a portion of the piping upstream of the valves. The resulting upstream pressure drop and the presence, or lack of, subcooled water upstream of the valves may be significant factors in the operation of the valves. Accordingly, these upstream piping configurations (i.e., short and self-draining and relatively long with trapped condensate or water seal) will be included in the full-scale valve tests to be performed at Combustion Engineering. (See Figures VI-1 through VI-4.) The piping supports will be instrumented to obtain piping load and response data.

2. <u>Discharge Piping</u>

The primary effect of the discharge piping system on safety and relief valve performance is believed to be the effect of back pressure. For this reason, and for flow measurement purposes, the proposed valve test program will include discharge piping and back pressure controls. In addition, it has been postulated that dynamic feedback effects from the downstream piping may have an effect on valve performance. For this reason, the discharge piping in the CE test facility will include a minimum of two 90° elbows and three straight runs of piping. As shown in Figures VI-1 through VI-4, these configurations will include several different piping sizes and lengths and will be instrumented to measure transient and steady-state pressures and reaction forces. The lengths of the piping runs are typical of those used in PWR plants. The numbers of straight runs and elbows were selected to provide a sufficient number of right angle turns and piping lengths to mock-up any significant feedback effects the piping may have on relief and safety valve operability. To confirm this, analyses will be performed of the related test configuration and a prototypical PWR valve discharge system. The results will be evaluated to verify that the significant effects are adequately modeled.

In addition to the experimental program, the PWR program for evaluation of piping analytical methods will include parallel analytical effort including the following main elements:

a. State-of-Art Survey of Piping Design Methods:

A survey has been initiated of NSSS, AE's, and piping design organizations to determine:

- Methods used for safety and relief valve discharge piping load prediction.
- Experimental or other verification data available to support these methods.

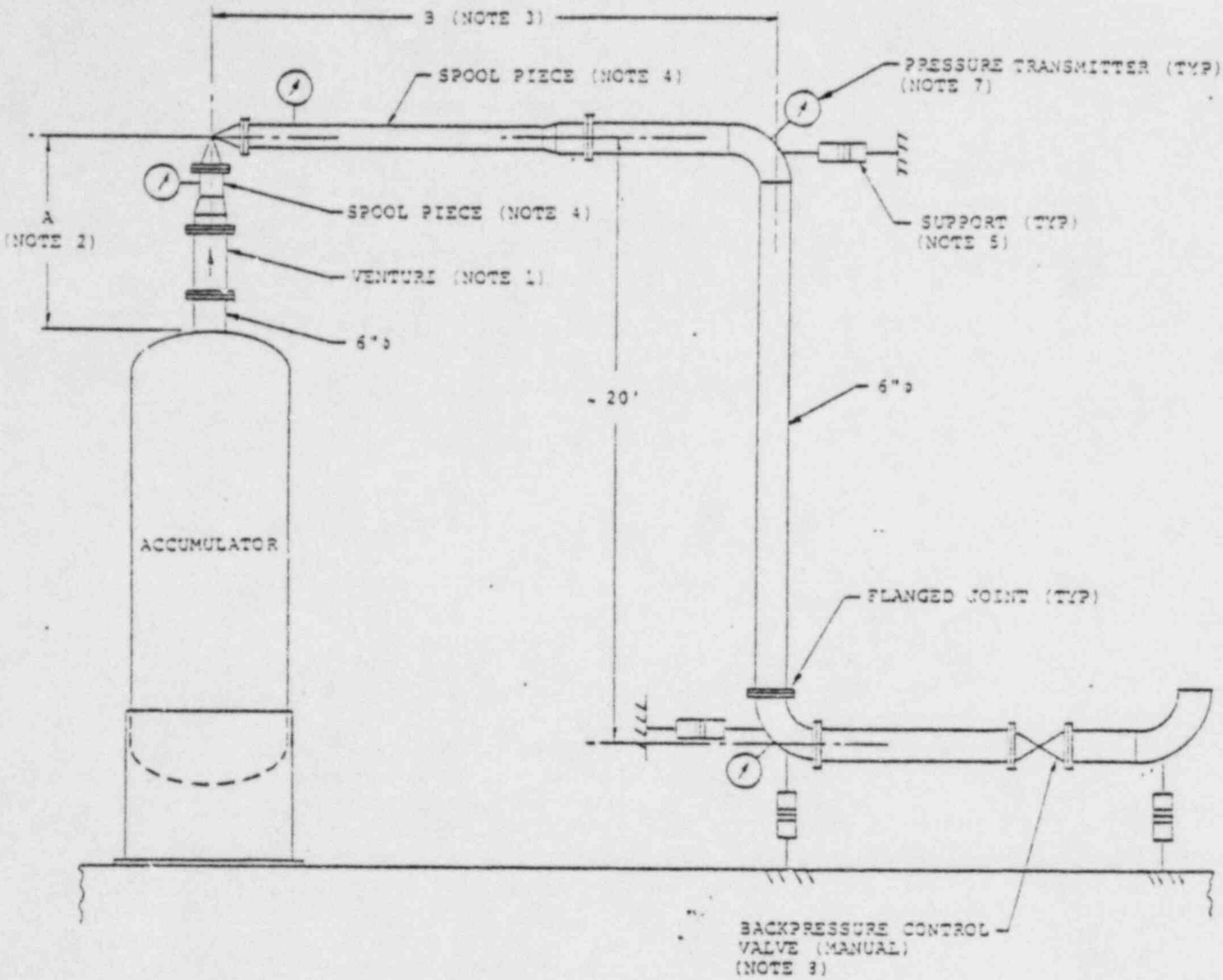
The results of this survey will be used to determine the state-of-the-art in the design and analysis of discharge piping systems.

b. Evaluation of Piping Analysis Methods

To the extent practical, piping load prediction methods used by NSSS, AE's and others will be evaluated. A key part of this effort will be the use of one or more sample problems which selected organizations will be requested to analyze for various fluid conditions. The sample problems will incorporate features typical of discharge piping systems (e.g., different length piping runs, elbows and valve opening times), and will include the discharge piping system selected for the full-scale valve performance tests. As discussed above, the analysis program will also include more complex discharge piping configurations representative of actual PWR installations to confirm that the test configurations adequately model the important parameters.

c. Development of Generic Piping Analysis Methods

It is expected that the state-of-the-art survey and evaluation of publicly available analytical programs for piping design will result in the selection of one or more specific generic methodologies believed best capable of predicting the hydraulic loads and piping response. These methods will be evaluated and together with the experimental data obtained in the full-scale valve performance test program, will be made available to PWR licensees. It should be noted that such an effort requires detailed evaluation of the test data and therefore will not be completed within the required test completion date of July, 1981.



• SEE SHEET 2 FOR NOTES

CONFIGURATION A

(CE TEST FACILITY)

FOR SHORT, VERTICAL, DRY INLET TO SAFETY VALVES

FIGURE VI-1

NOTES TO FIGURE VI-1

1. ASME type venturi

2. Length "A" to be as short as possible while accommodating the different safety valve inlet, outlet, and loop seal (see Figure 2) geometries.

3. Length "B" to be within 4 to 8 feet depending on the facility constraints.

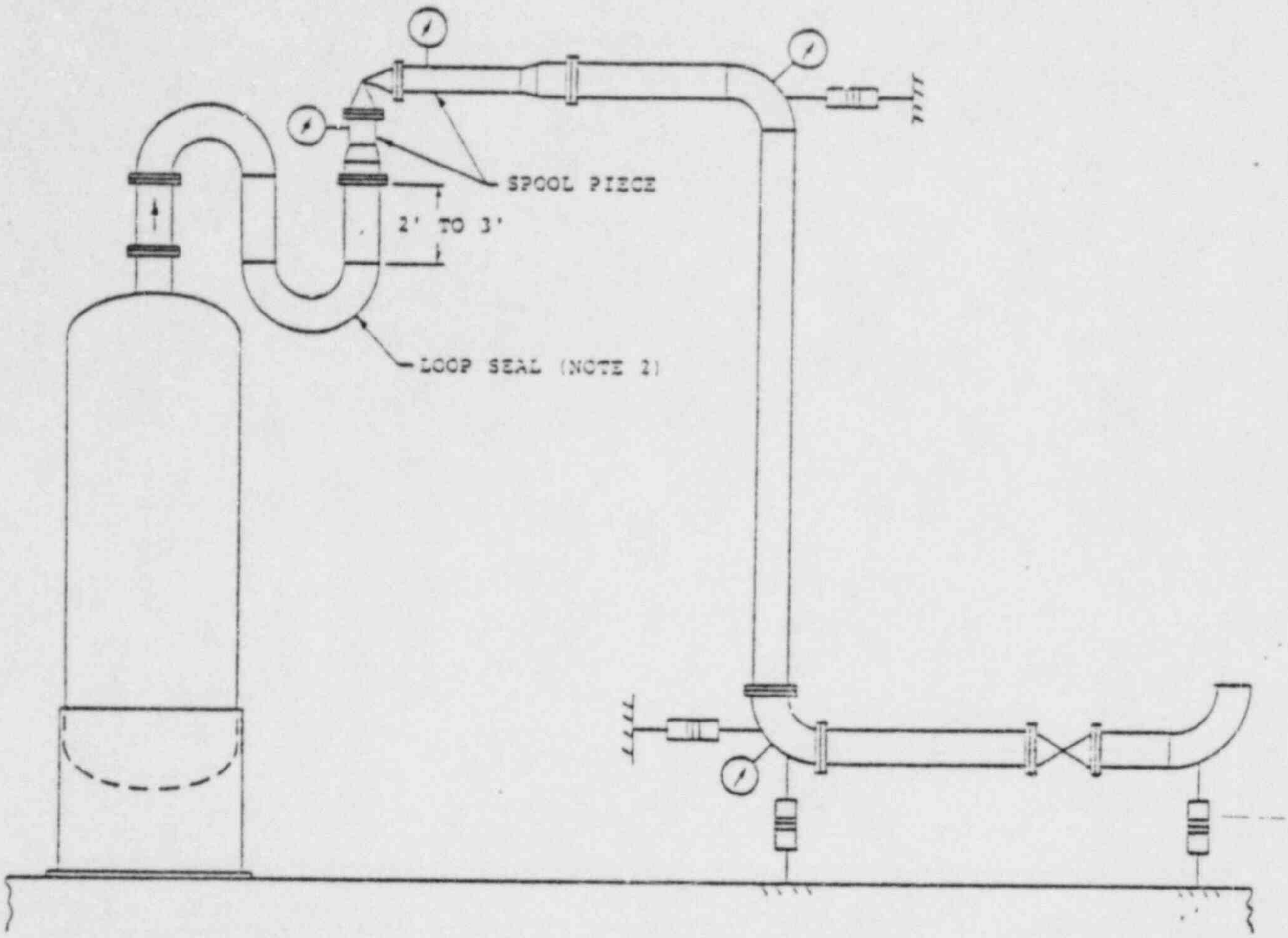
4. The spool piece lengths and diameters should be consistent with the valve dimensions and lengths "A" and "B".

5. The piping support types are to be determined by the contractor from piping flexibility analyses. If necessary, an expansion joint may be used in length B.

6. The piping supports should include load cells for measuring transient reaction forces.

7. One pressure sensor is required at the discharge of the safety valve to measure backpressure. Two pressure sensors are required at the piping elbows for estimating transient reaction forces. One pressure sensor is required at the valve inlet for measuring inlet pressure. (Sensor locations shown are preliminary).

8. An orifice can be used in place of the backpressure control valve if desired.



NOTES

1. PIPING, PRESSURE SENSORS, SUPPORTS, VENTURI, ETC., ARE THE SAME AS THAT SHOWN IN CONFIGURATION A (FIGURE 1), EXCEPT FOR THE LOOP SEAL AT THE SAFETY VALVE INLET AND THE SPOOL PIECES.

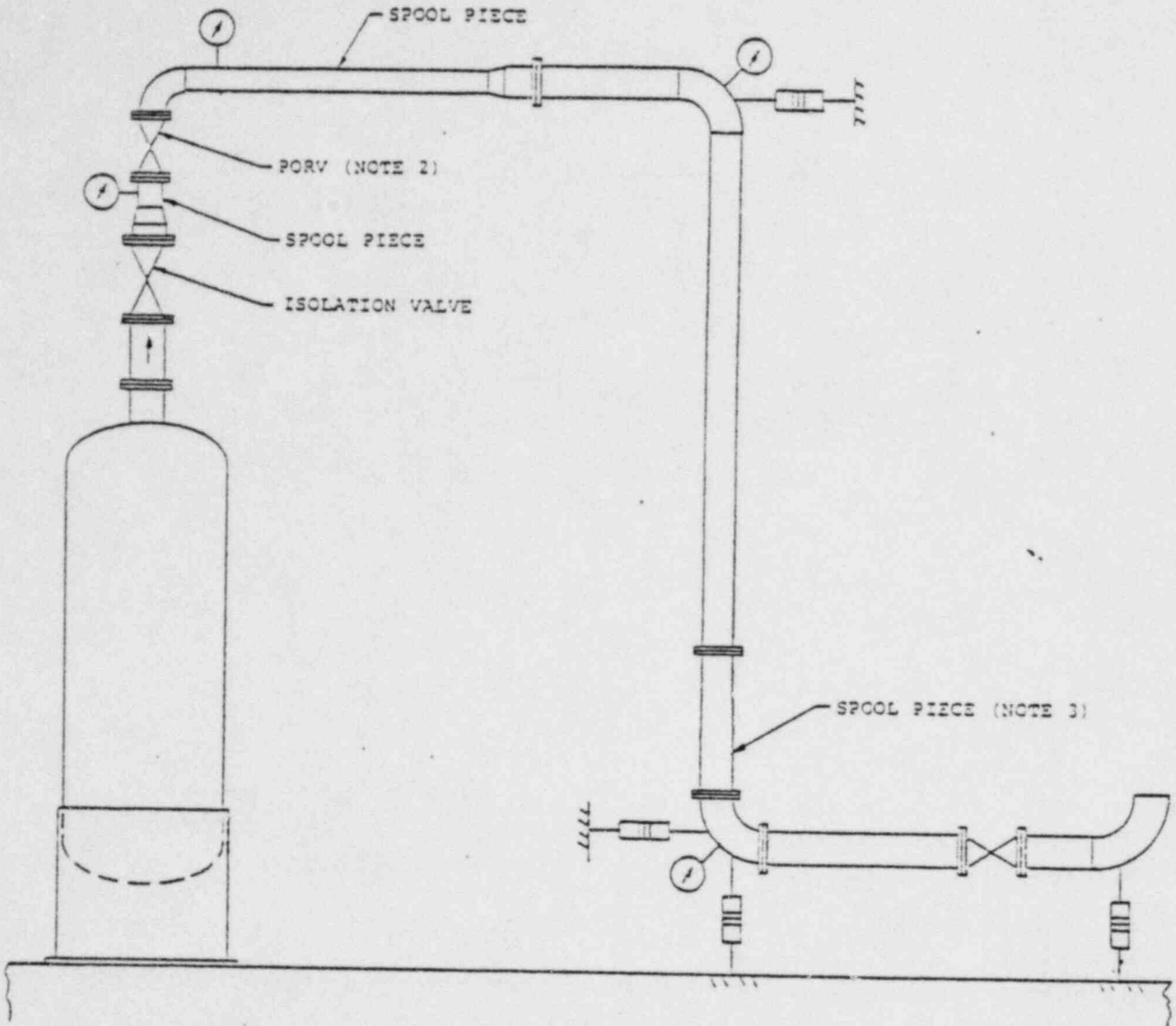
2. THE LOOP SEAL SHOULD BE CONSTRUCTED OF FOUR 6" LONG RADIUS ELBOWS WITH 2' TO 3' STRAIGHT VERTICAL SECTIONS AS SHOWN.

CONFIGURATION B

(CE TEST FACILITY)

FOR LOOP SEALS FOR SAFETY VALVES

FIGURE VI-3



NOTES

1. PIPING, PRESSURE GAGES, SUPPORTS, VENTURI, ETC., ARE THE SAME AS THAT SHOWN IN CONFIGURATION A (FIGURE 1), EXCEPT FOR THE ISOLATION VALVE AT THE PORV INLET.

2. A 90 DEGREE LONG RADIUS ELBOW SHOULD BE USED AT THE INLET OF A PORV MOUNTED HORIZONTALLY.

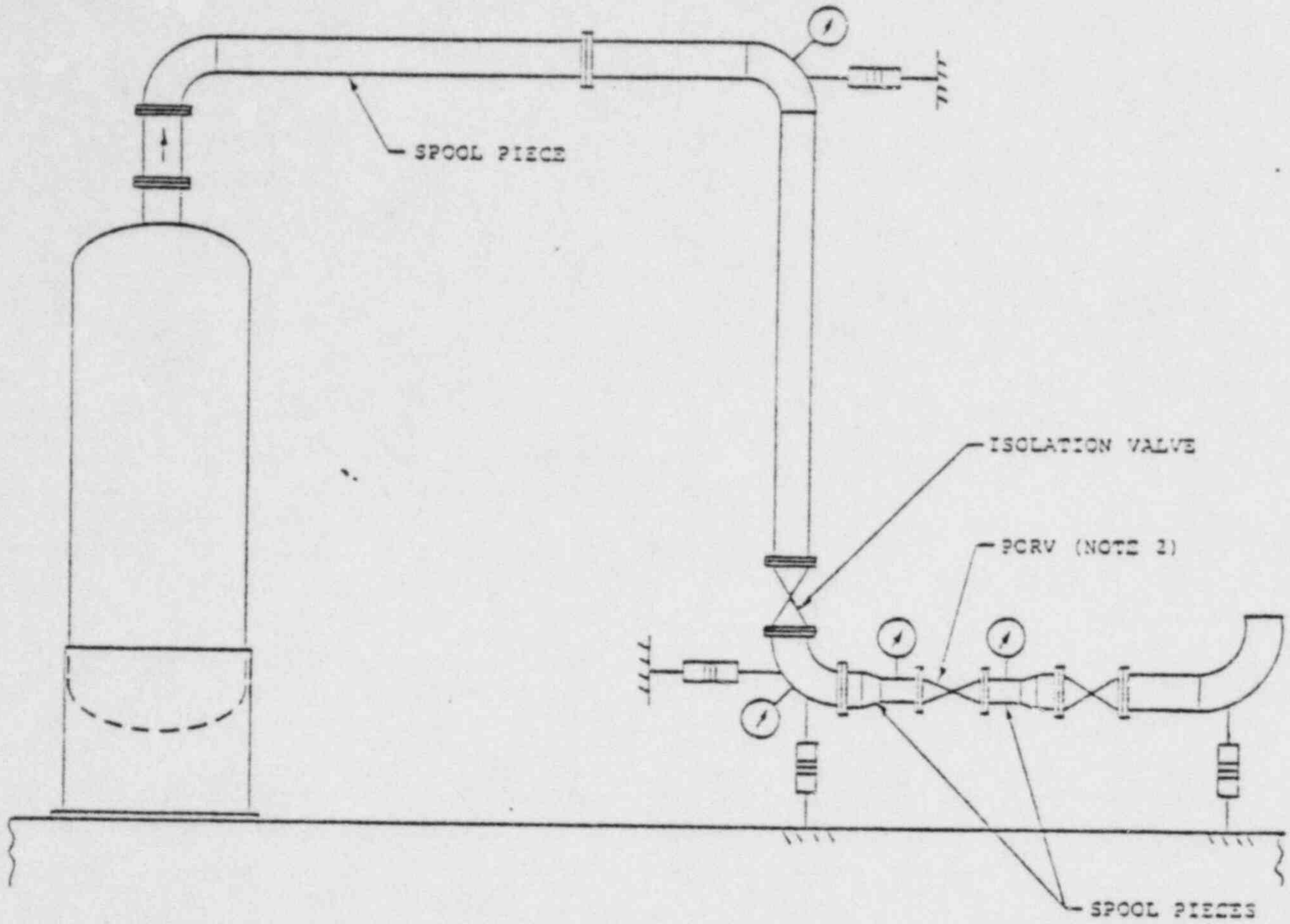
3. A SPOOL PIECE MAY BE REQUIRED IN THE [illegible] OUTLET PIPING TO ACCOUNT FOR THE ADDED [illegible] THE ISOLATION VALVE AND 90° ELBOW AT PORV [illegible]

CONFIGURATION C

(CE TEST FACILITY)

SHORT VERTICAL DRY INLET FOR PORV

FIGURE VI-3



NOTES

1. BASIC PIPING DIMENSIONS, PRESSURE SENSORS, SUPPORTS, VENTURI, ETC., ARE THE SAME AS THAT SHOWN IN CONFIGURATION A (FIGURE 1), EXCEPT FOR THE ISOLATION VALVE AND SPOOL PIECES.

2. 90° ELBOWS WILL BE REQUIRED AT THE INLETS AND OUTLETS OF PORV'S THAT MUST BE MOUNTED VERTICALLY.

CONFIGURATION D

(CE TEST FACILITY)

LONG INLET FOR PORV'S

FIGURE VI-4

VII. APPENDICES

APPENDIX A

PRELIMINARY WORKSCOPE FOR THE
RELIEF VALVE TEST PROGRAM
AT THE MARSHALL STEAM STATION

TABLE OF CONTENTS

A. Scope

1. Purpose

The purpose of these tests is to obtain performance data on pressurized water reactor primary system relief valves under steam flow conditions.

2. Test Overview

Full flow tests of six power operated relief valves (PORVs) are to be conducted. Each valve will be tested with steady state steam flow (Figure A). A range of valve backpressure will be covered. The tests will be conducted using a relief valve test facility at Marshall Steam Station - Unit 2.

Data will be obtained to determine valve flow, inlet and outlet pressure, stroke time, and temperatures. Valve leakage from zero to 10 gpm ($\pm$ 1/2 gpm) will be measured before and after valve testing.

B. Valve Types

The following valves will be supplied by EPRI:

Valve Type	Size	Manufacturer	Model No.
Relief Valve (Pressurmatic)	2 1/2"x4"	Crosby	HPV-SN
Relief Valve (Electromatic)	2 1/2"x4"	Dresser	31533VX-30
Relief Valve (Air-Operated)	3"	Control Components	3" Drag
	3"	Copes Vulcan	3" - 1500
	3"	Fisher Controls	SS-103-SS-95
	(Later)	Masoneilan	(Later)

C. Piping Configurations

The PORV inlet and outlet piping configurations are shown in Duke Power Company Drawings: (later)

D. Instrumentation Requirements

Instrumentation is required to measure the test system and test valve parameters listed in Table 1. A summary of the measurement system requirements including range, frequency content and accuracy is provided in Table 2.

E. Data Acquisition and Reduction Requirements

The following data acquisition system capability shall be provided:

- ° All data channels that can provide a compatible signal (a maximum of 15) shall be recorded on FM tape for later reduction and as a permanent record.

- ° Pen recorder type plots of up to 15 selected data channels shall be provided. Calibration constants should be documented on a form traceable to each plot.

F. Facility Requirements

The test facility is capable of achieving the fluid system flow rates and conditions to conduct the tests specified in paragraph G below. Principal facility parameters are as follows:

- ° Maximum test pressure 2500 psia
- ° Maximum test temperature - saturation at 2500 psia
- ° Estimated Maximum Capacity - 210,000 lbs/hr of saturated steam;

° Back pressure

- Capability to control back pressure

° System Cleanliness

- System cleanliness must be maintained such that normal valve operation and instrumentation are not affected by contaminants in the system.

G. Tests

1. Facility and Instrumentation Check-Out and Acceptance

Duke Power Company shall conduct check-out tests of the facility and instrumentation. The purpose of these check-out tests is to operate the test facility under steam test conditions to assure the facility operates as designed and is adequately supported. These tests are to be performed using the CCI 3" drag type PORV, and will provide data to verify facility operation including proper range of instrumentation for measurement of fluid parameters (flow rate, pressures, etc.).

2. Performance Tests

Performance tests are required for each valve type specified in paragraph B above, for the fluid transient conditions, and back pressures specified in Table 3.

3. Post-Test Inspection/Checkouts

Following each test series, the test valve shall undergo the following at the direction of a technical representative of that particular valve company:

- o Visual examination
- o Refurbishment, if required, to meet seat leakage requirements.

After successful completion of an entire test sequence for a given valve, the valve shall be disassembled, inspected and photographed. Results of all inspections and tests shall be documented.

H. Acceptance Criteria

Acceptance criteria will be provided by EPRI.

I. Quality Assurance Provisions

1. QA Program

The test program described herein shall be performed under a QA program designed to ensure traceability of components and provide complete documentation of tests and results.

2. Calibration Requirements

Instrumentation calibration in conjunction with this program shall be traceable to the National Bureau of Standards.

3. Procedures

All tests shall be performed in accordance with written procedures and approved by EPRI. These procedures shall include step-by-step test requirements and acceptance criteria.

4. Witness/Access

EPRI will have a site manager involved in the day to day conduct of the test program. Access to the test facility by others will be coordinated by the site manager or the EPRI project manager.

J. Reporting and Documentation Requirements

The following documentation should be submitted to EPRI:

Documentation

o system schematics

o system isometrics and component arrangement drawings

- system hydraulic loading and thermal stress analyses (for information, only)

- instrumentation description including types, locations, ranges, accuracies, response times, etc.

- quality assurance information including calibration, traceability, as-built dimensions, etc.

TABLE 1

TEST SYSTEM MEASUREMENTS

MEASUREMENT	TRANSDUCER	LOCATION	NUMBER
A. Steam Pressure	Pressure	- Upstream of Test Valve - Downstream of Test Valve	1 1
B. Flow Rate Through Test Valve	Differential Pressure	- Flow Orifice Upstream of Test Valve	1
C. Steam Temperature	Thermocouple/RTD	- Upstream of Test Valve - Downstream of Test Valve	1 1
D. Test Valve Body Temperature	Thermocouple/RTD	- Test Valve Surface Temperature	3
E. Test Valve Acceleration	Accelerometer	- Test Valve X-Axis - Test Valve Y-Axis - Test Valve Z-Axis	1 1 1
F. Test Valve Seat Position (includes measurement of opening/closing time where practicable)	LVDT on Air Operated or Acclerometer on Pilot Operated	- Test Valve	1
G. Valve Operator Input Parameters	Air Pressure or Electrical Current	- Test Valve Operator	1

TABLE 2

MEASUREMENT REQUIREMENTS SUMMARY

MEASUREMENT	RANGE	ACCURACY[1]
A. Pressure	0 - 3000 psia	± 1%
B. Differential Pressure across Flow orifice	0 - 440" W.D.	± 5% or better
C. Temperature	100° - 700°F.	± 1%
D. Acceleration	2/	± 3%
E. Valve Position	0 - 100%	± 5%
F. Valve Operator Parameters		
o air operator	0 to 200 psi	± 5% or better
o motor operator	0 to 5 amps	± 5% or better

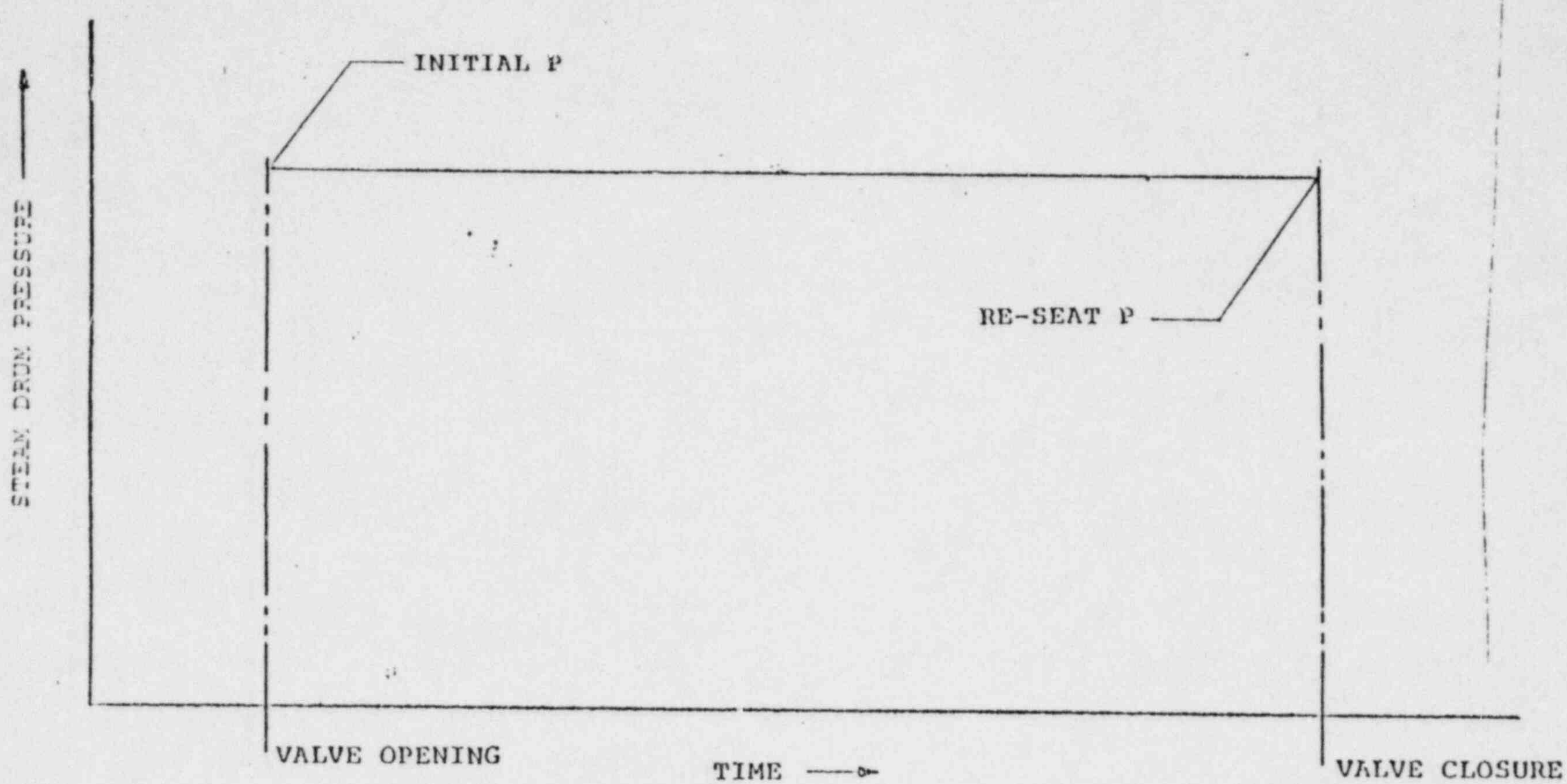
NOTES:

1. Ratio of the error (2σ) to the full-scale output based on all error components of transducer, signal conditioner, data acquisition and reduction system.

2. Parameter value to be determined.

TABLE 3: RELIEF VALVE TEST MATRIX

TEST VALVE	FLUID CONDITIONS							NUMBER OF TESTS
	INITIAL BOILER CONDITIONS			TRANSIENT CONDITIONS				
	P_0 (psia)	T_0 (°F)	FLUIDS	RE-SEAT P (psia)	TRANSIENT DESCRIPTION	BACK PRESSURE (psia)		
A. PORVs (Solenoid Pilot-Operated) ° Crosby HPV-SN ° Dresser 31533VX-30	2500 (nominal)	sat.	Steam	<2500	Steam Flow, See Figure A	100 & 500		20 Tests
B. PORVs (Air-Operated) ° Control Components 3" Drag ° Copes Vulcan 3" - 1500 ° Fisher Controls :S-103-SS-95 ° Masoneilan (Later)	2500 (nominal)	sat.	Steam	<2500	Steam Flow, See Figure A	100 & 500		36 Tests
								56 Tests



FLUID TRANSIENT CONDITIONS FOR TYPICAL STEAM TESTS

FIGURE A

APPENDIX B

PRELIMINARY WORKSCOPE FOR THE RELIEF VALVE TEST PROGRAM AT THE WYLE FACILITY

TABLE OF CONTENTS

A. Scope

1. Purpose

The purpose of these tests is to obtain performance data on pressurized water reactor primary system relief valves for the range of fluid conditions under which they may be required to operate.

2. Test Overview

Full flow tests of two power operated relief valves (PORV's) are to be conducted. Each valve will be tested with steam flow and with water flow. Several set pressures and backpressures will be covered.

Blowdown type tests will be conducted using the relief valve test facility shown in Figure 1. Steam and water tests will be conducted as follows:

Steam Tests: The existing 300 ft^3 vessel (V-2) will be filled with saturated steam at test pressure. The PORV will be mounted off the bottom of V-2 and will be electrically actuated to open. Steam will be discharged by the PORV until it is electrically actuated to close. (Figure 2)

Water Tests: The existing 300 ft^3 vessel (V-2) will be partially filled with saturated water at test temperature. The existing 600 ft^3 vessel (V-1) will be filled with nitrogen and will serve as a driver for V-2. The isolation valve between V-1 and V-2 will be opened just prior (10 seconds) to the start of the test and the nitrogen will pressurize V-2 to the test pressure. The PORV will be electrically actuated and stay open until it is electrically actuated to close.

Data will be obtained to determine valve flow, inlet pressure, reaction loads and temperatures. Valve leakage after valve closure will also be measured from 0 to 10 gpm ± 1/2 gpm.

B. Valve Types

The following valves* will be supplied by EPRI:

Valve Type	Size	Manufacturer	Model No.
- Relief Valve (Pressurmatic)	2 1/2" x 4"	Crosby	HPV-SN
- Relief Valve (Electromatic)	2 1/2" x 4"	Dresser	31533VX-30

C. Piping Configurations

The PORV inlet and outlet piping configurations are shown in Figure 3.

D. Instrumentation Requirements

Instrumentation is required to measure the test system and test valve parameters listed in Table 1. A summary of the measurement system requirements including range, frequency content and accuracy is provided in Table 2.

* An optional test series for the air operated relief valves shown in Table III-5 is presently being developed for the Wyle Test Facility. Methods for incorporating the principal effects of discharge piping on valve operability for the Wyle tests are presently being evaluated.

E. Data Acquisition and Reduction Requirements

1. Data Acquisition

The following data acquisition system capability shall be provided:

- All data channels (a maximum of 40) shall be recorded for later reduction and as a permanent record. Analog, PCM or direct computer acquisition may be used. Maximum signal frequency can be estimated at 300 Hz for 20 channels, 50 Hz for 10 channels and 10 Hz for 10 channels. Data channels shall be sampled at ten times their maximum frequency.
- Quick-look plots of up to 15 selected data channels shall be provided within a one hour period following the test. Either oscillograph records or reduced data plots are acceptable.

2. Data Reduction

All data channels shall be reduced to engineering unit plots within a one day period following the test. Plots shall be 8-1/2 x 11 inches and of report quality.

F. Facility Requirements

The test facility shall be capable of achieving the fluid system flow rates and conditions specified in paragraph G below. Principal facility requirements are as follows:

- Maximum test pressure - 2700 psia
- Maximum test temperature - 680° F
- Estimated capacity - 200,000 lbs/hr of saturated steam; 1000 gpm of saturated water at 2500 psia or transient subcooled water up to 5,000 gpm.
- Valve inlet (V-2) fluid conditions -
  - Saturated steam
  - Subcooled water (500 - 2700 psia at temperatures from 300- 650°F)
- Back pressure
  - Dynamic back pressure up to 500 psig

In addition, the facility shall have the capability to perform tests under all specified fluid conditions with a fixed orifice in place of any test valve. This will require that the facility provide rupture discs to permit facility check-out for all specified test conditions and transients.

- Valve Body and Piping Temperatures
  - The vessels, test valves and piping shall be insulated and heated to achieve the test conditions specified in Section G below.
- System Cleanliness
  - System cleanliness must be maintained such that normal valve operation and instrumentation are not affected by contaminants in the system.

G. Tests

1. Facility and Instrumentation Check-out and Acceptance

The Contractor shall prepare, for EPRI approval, a test specification for check-out of the test facility and instrumentation and to provide base-line data for system check-out. The purpose of these check-out tests will be to operate the test facility under both steam and water test conditions to assure the facility operates as designed and is adequately supported. These tests may be performed using one of the test PORV's or a fixed orifice. In either case, the water tests should include intermediate pressures of 500 and 1500 psi, and the steam tests should include an intermediate pressure of 500 psi, prior to operation at maximum specified pressures. The tests will provide data to verify facility operation as well as measurements of fluid parameters (flow rate, pressures, etc.) and valve parameters (reaction forces and accelerations).

2. Performance Tests

Performance tests are required for each of the valve types specified in paragraph B above, for a series of different fluid transient conditions and back pressures as specified in Table 3.

3. Post-Test Inspection/Checkouts

Following each test series, the test valve shall undergo the following at the direction of a technical representative of that particular valve company. The Contractor shall notify the representatives to be present during their respective test periods.

- Visual examination
- Seat leakage test
- Refurbishment, if required, to meet seat leakage requirements.

After successful completion of an entire test series for a given valve, the valve shall be disassembled, inspected and photographed. Results of all inspections and tests shall be documented.

H. Acceptance Criteria

Acceptance criteria will be provided by EPRI.

I. Quality Assurance Provisions

The test program described herein shall be performed under a formal QA program which meets applicable requirements.

J. Reporting and Documentation Requirements

The following documentation should be submitted to EPRI for approval:

Documentation

- system schematics
- system isometrics and component arrangement drawings
- system hydraulic loading and thermal stress analyses (For info only.)

Documentation

- instrumentation description including types, locations, ranges, accuracies, response times, etc.
- test specification
- quality assurance manual

TABLE 1

TEST SYSTEM MEASUREMENTS

MEASUREMENT	TRANSDUCER	LOCATION	NUMBER
A. Vessel Pressure	Pressure	- Vessel V-1	1
		- Vessel V-2	1
B. Flow Pressure Drop	Differential Pressure	- Between Vessels V-1 and V-2	1
		- Vessel V-2 to Upstream of Test Valve	1
		- Across Test Valve	1
		- Across Back-Pressure Valve (or Orifice)	1
		- From Exit of Back-Pressure Valve to Atmosphere	1
C. Flow Rate Through Test Valve	Differential Pressure	- Flow Venturi Upstream of Test Valve	2
D. Water Level in Vessel V-2	Differential Pressure	- Vessel V-2	2
E. Fluid Temperature	Thermocouple/RTD	- Vessel V-1	2
		- Vessel V-2	2
		- Upstream of Test Valve	1
		- Downstream of Test Valve	1
		- Downstream of Back-Pressure Valve	1
F. Test Valve Acceleration	Accelerometer	- Test Valve X-Axis	1
		- Test Valve Y-Axis	1
		- Test Valve Z-Axis	1
G. Piping Support Reaction Loads	Load Cell	- At Each Piping Support Location	3
H. Test Valve Position	LVDT on air operated or Accelerometer on pilot oper.	- Test Valve	1
I. Valve Operator Input Parameters	Air Pressure or Electrical Power	- Test Valve Operator	1
J. Valve Body Temperature	Thermocouple	- Test Valve Body	2
K. Test Valve Position Monitor	Acoustic	- On Test Valve with None Interference Basis	1

TABLE 2

MEASUREMENT REQUIREMENTS SUMMARY

MEASUREMENT	RANGE	MAXIMUM PARAMETER FREQUENCY	ACCURACY[1/]
A. Pressure	0 - 3000 psia	50 Hz	1%
B. Differential Pressure			
- Flow pressure drop	3/	300 Hz	2%
- Flow venturi	0 - 50 psid	300 Hz	5%
- Water level	0 - 25 psid	50 Hz	1%
C. Temperature	0 - 700°F	10 Hz	1%
D. Acceleration	2/	300 Hz	3%
E. Reaction Load	2/	300 Hz	3%
F. Valve Position	2/	50 Hz	2/
G. Valve Operator Parameters	2/	50 Hz	2/

NOTES:

1. Ratio of the error (2σ) to the full-scale output based on all error components of transducer, signal conditioner, data acquistion and reduction system.

2. Parameter value to be determined.

3. Ranges are as follows:

   - Between Vessels V-1 and V-2 - 0 - 500 psid
   - Vessel V-2 to Upstream of Test Valve - 0 - 100 psid
   - Across Test Valve - 0 - 3000 psid
   - Across Back-Pressure Valve (or Orifice) - 0 - 500 psid
   - From Exit of Back-Pressure Valve to Atmosphere - 0 - 200 psid

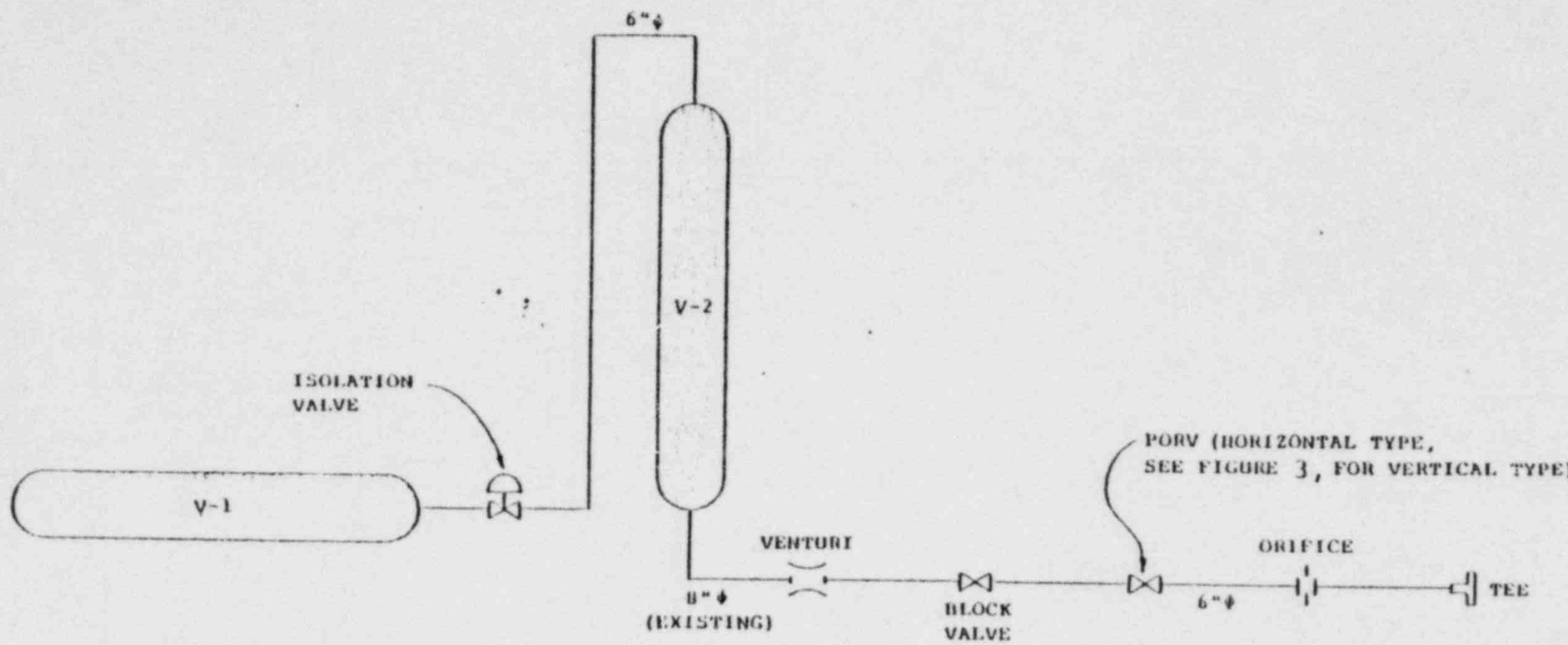
TABLE 3

TEST MATRIX

TEST VALVE	INLET PIPING	FLUID CONDITIONS									REMARKS
		INITIAL ACCUMULATOR CONDITIONS			TRANSIENT CONDITIONS						
		P_0 (PSIA)	T_0 (°F)	FLUIDS	SET OR ACTUATION P (PSIA)	P RAMP RATE (PSI/SEC)	REQUIRED PEAK P (PSIA)	RE-SEAT P (PSIA)	TRANSIENT DESCRIPTION	BACK PRESSURE (PSIA)	
PORVs (Solenoid Pilot-Operated)	Vertical Configuration	2700	680	Steam	2700	(1)	2700	2300	Steam Flow, See Figure 2	100 and 500	4 Tests
* Crosby HPV-SN		2700	650	Water	2700	(1)	2700	2300	Water Flow, See Figure 2 (2)	100 and 500	4 Tests
* Dresser 31533VX-30		2700	550	Water	2700	(1)	2700	2300	Water Flow, See Figure 2 (2)	100	2 Tests
		2700	450	Water	2700	(1)	2700	2300	Water Flow, See Figure 2 (2)	100	2 Tests
		500	467	Steam	500	(1)	500	400	Steam Flow, See Figure 2	100	2 Tests
											14 Tests

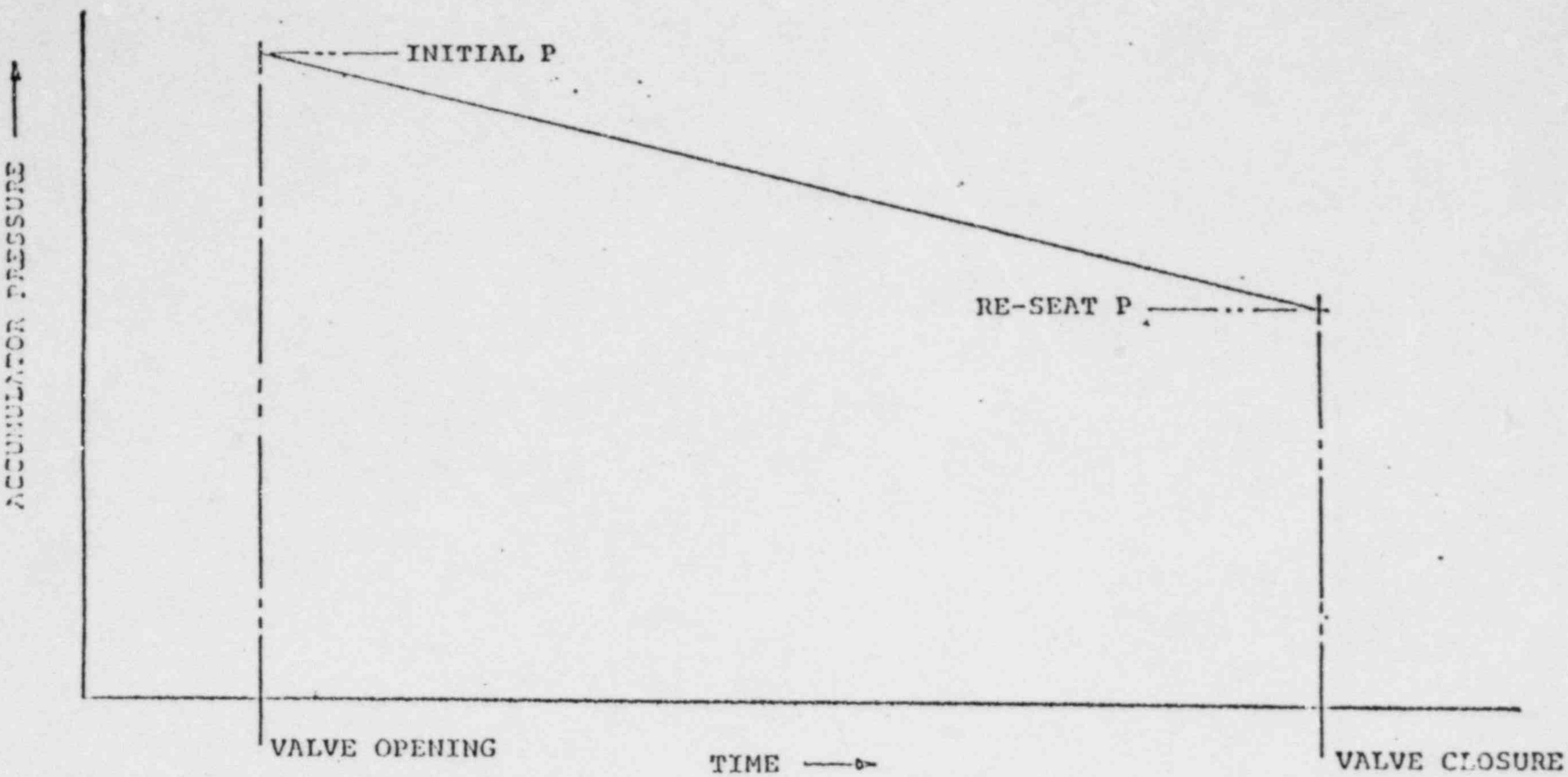
NOTE (1) The test will be initiated by electrically actuating the PORV; therefore, the pressure ramp rate will be zero.

(2) These are fixed-flow tests with a liquid flow rate of approximately 1000 gpm.



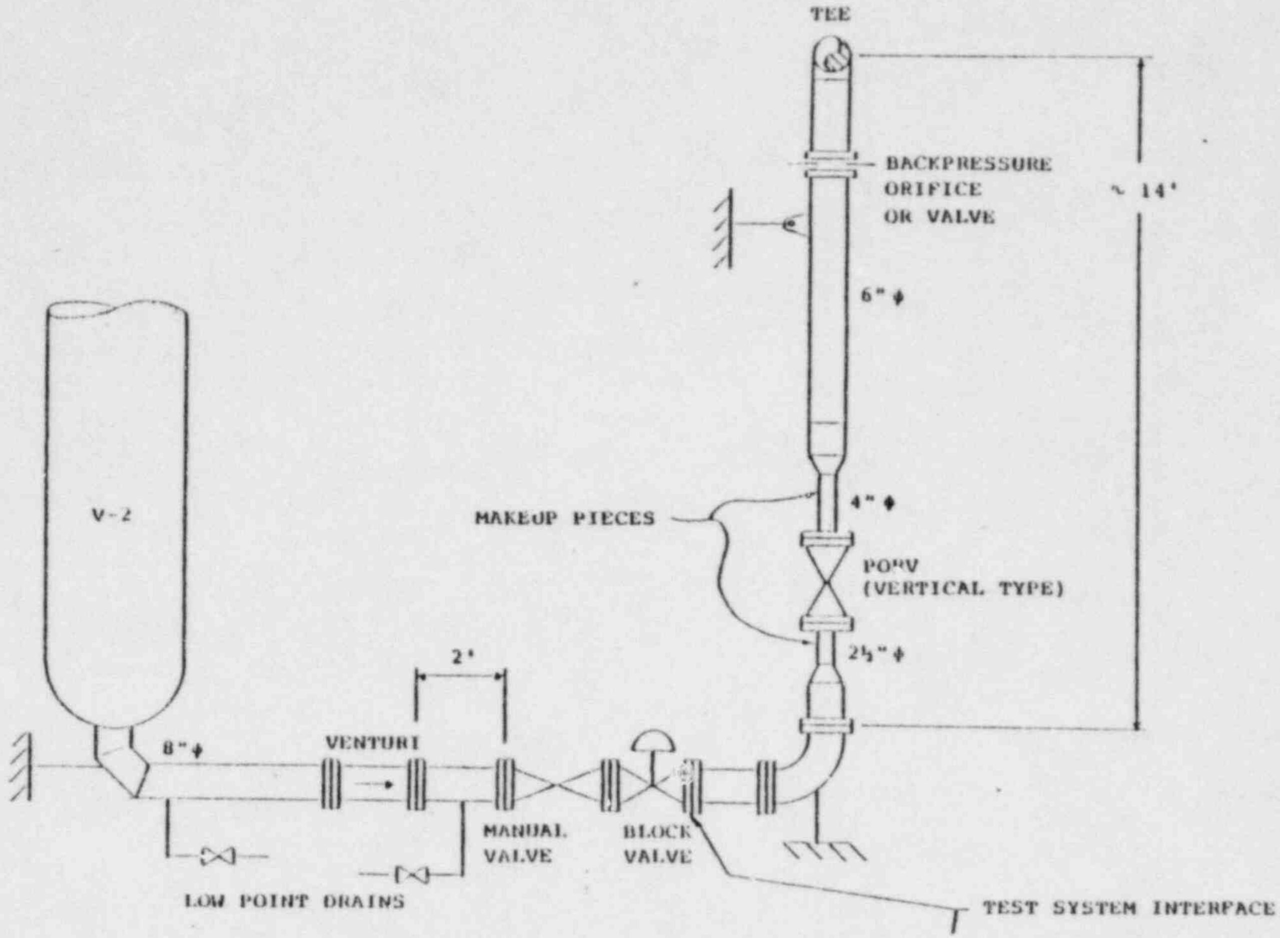
WYLE VALVE TEST FACILITY

FIGURE 1



FLUID TRANSIENT CONDITIONS FOR TYPICAL RELIEF VALVE (STEAM OR WATER) TESTS

FIGURE 2



WYLE PORV INLET AND DISCHARGE PIPING

FIGURE 3

APPENDIX C

PRELIMINARY WORKSCOPE FOR THE SAFETY AND RELIEF VALVE TEST PROGRAM AT THE COMBUSTION ENGINEERING FACILITY

TABLE OF CONTENTS

A. Scope

1. Purpose

The purpose of these tests is to obtain performance data on pressurized water reactor primary system safety and relief valves and inlet and discharge piping for the range of fluid conditions under which they may be required to operate.

2. Test Overview

Flow tests of safety and relief* valves are required under water, steam and transition (steam to water) flow conditions. Several back pressures and various inlet and discharge piping configurations will be covered. Quasi-static type tests will be conducted (Figure 1) with the facility arrangement shown schematically in Figure 2.

Data will be obtained to determine valve flow, test system temperatures, pressures and piping loads. Valve leakage after valve closure will also be measured from 0 to 10 gpm ± 1/2 gpm.

---

* Similar relief valve tests under steam and water conditions are presently planned at Marshall and Wyle facilities, respectively. Where appropriate, the Marshall and Wyle results will replace those cooresponding tests planned for Combustion Engineering.

B. Valve Types

The following valves will be supplied by EPRI for test:

Valve Type	Size	Manufacturer	Model #
Safety Valve (spring-loaded)		Crosby Dresser	HB-BP-86 (6M6) 31739A 31709NA
Safety Valve (pilot-operated)		Target Rock	69C
Relief Valve (Pressurmatic)	2 1/2" x 4"	Crosby	HPV-SN
Relief Valve (Electromatic)	2 1/2" x 4"	Dresser	31533VX-30
Relief Valve (Air-Operated)	3"	Control Components	3" Drag
	3"	Copes Vulcan	3" - 1500
	(Later)	Fisher Controls	SS-103-SS-95
	(Later)	Masoneilan	(Later)

C. Piping Configurations

The inlet and discharge piping configurations for the safety and relief valve tests are shown in Figures 3 through 6.

D. Instrumentation Requirements

Instrumentation is required to measure the test system and test valve parameters listed in Table 1. Other facility instrumentation will include process instrumentation for operating and controlling the test system.

E. Data Acquisition and Reduction Requirements

1. Data Acquisition

The following data acquisition system capability is required:

- All data channels will be recorded for later reduction and as a permanent record. Maximum signal frequency is estimated at 200 Hz for 22 channels, 20 Hz for 21 channels and 2 Hz for 13 channels. Data channels will be sampled at six times their maximum frequency. Combined sampling rate for all channels is approximately 30,000 samples per second.

- Quick-look plots of up to 15 selected data channels will be provided within a one hour period following the test. Either oscillograph records or reduced data plots will be provided.

2. Data Reduction

All data channels will be reduced to engineering unit plots within a three day period following the test. Plots will be 8-1/2 x 11 inches of report quality.

F. Facility Requirements

1. Test Facility Modification

The Contractor will redesign and modify an existing test facility at CE's Kreisinger Development Laboratory at Windsor, Connecticut to meet the requirements of this program. The major modifications that will be completed include: (1) installation of two accumulator tanks to supplement the existing test boiler capacity; (2) construction of the required foundations and structures to support accumulator tanks and the various inlet and discharge piping configurations; (3) fabrication of the inlet and discharge piping; and (4) extension of the high-bay facility to house the test system.

The test loop will be rated at 3250 psig and 700°F. The test facility will be capable of performing quasi-steady-state tests with sufficient test duration to obtain valid valve operability and performance characteristics.

G. Tests

1. Facility and Instrumentation Checkout

The Contractor will perform checkout tests of the test facility and instrumentation and to provide baseline data prior to performance of valve tests. The purpose of these checkout tests will be to approximate specified fluid conditions, pressures and flow rates that will be experienced during valve tests using a fixed orifice in place of the test valves. The tests will provide data to verify proper facility operation as well as measurements of fluid and valve parameters. In addition, static load tests will be performed as needed to calibrate piping and support strain gages and load cells in order to permit dynamic measurement of piping and valve reaction loads. During these tests loop process and control instrumentation will also be evaluated.

Contractor will also perform a total of eight scoping tests on the test valves provided by EPRI. The valves will be tested at pressures between 2300-2600 psia. The purpose of these tests will be to determine:

- Adequate test durations for such valves.

- Adequacy of test facility and measurements.
- Ability of Contractor to quantify valve leak tightness.
- The calibration range for piping structural response instrumentation.

2. Performance Tests

Performance tests on four safety valves and six relief valves provided by EPRI are required. A total of 88 tests are planned. As mentioned earlier, the relief valve test results obtained from Marshall and Wyle facilities will replace, where appropriate, corresponding tests presently planned for Combustion Engineering. The number of tests to be performed on each test valve is detailed in Table 2. The fluid conditions and inlet and discharge piping configurations are also shown in Table 2.

3. Post-Test Inspection/Checkouts

Contractor will allow for post-test inspection and checkout of the test valves. This inspection and checkout will alow for visual examination and a seat leakage test.

After successful completion of an entire test series for a given test valve, Contractor will allow for a technical representative of the valve manufacturer to disassemble, inspect, and photograph the test valve.

H. Analytical Support

Contractor will perform hydraulic analyses of the test system. Adequacy of the test loop configuration including piping lengths and sizes, tank sizes and water to steam ratios, initial thermodynamic conditions, and mode of operation will be evaluated.

Hydrauli~ analysis results will be input into structural calculations to compute reaction forces and define restraint o. support load requirements. Different piping configurations, and tests for water, steam, and transition conditions will be included. The analytical models will include the inlet and discharge configurations in order to determine the maximum support load requirements.

The Contractor will perform analytical predictions for comparison with actual test results. Refinements to the analytical models will be made as required based on these comparisons. Analytical models developed will also simulate the test valve inlet and discharge configurations.

I. Acceptance Criteria

Contractor and EPRI will develop test acceptance criteria for each valve to be tested.

J. Quality Assurance Provisions

The test program will be performed under a formal quality assurance program, prepared by the Contractor in accordance with applicable requirements.

All tests shall be performed in accordance with written procedures prepared by Contractor.

K. Reporting and Documentation Requirements

The Contractor shall provide a final report which includes:

- A description of the as-built test facility.
- The test results obtained during the program.
- The results of the analytical evaluations.

In addition, the Contractor shall provide interim data reports to EPRI.

TABLE 1

COMBUSTION ENGINEERING VALVE TEST FACILITY - TEST SYSTEM MEASUREMENTS[1/]

MEASUREMENT	TRANSDUCER	LOCATION	NUMBER OF CHANNELS	MAXIMUM FREQUENCY (Hz)
A. Vessel Pressure	Pressure	- Vessel V-1	1	20
		- Vessel V-2	1	20
B. Flow Pressure Drop	Differential Pressure	- Between Vessels V-1 and V-2	1	20
		- Vessel V-1 to Upstream of Test Valve	1	20
		- Across Test Valve	1	20
		- Across Discharge Piping	3	20
		- Across Back-Pressure Valve (or Orifice)	1	20
		- From Exit of Back-Pressure Valve to Atmosphere	1	20
C. Flow Rate through Test Valve	Differential Pressure	- Flow Venturi Upstream of Test Valve	2	20
D. Water Level	Differential Pressure	- Vessel V-1	2	20
		- Vessel V-2	2	20
E. Fluid Temperature	Thermocouple	- Vessel V-1	2	2
		- Vessel V-2	3	2
		- Upstream of Test Valve	1	2
		- Downstream of Test Valve	1	2
		- Downstream of Back-Pressure Valve	1	2
F. Test Valve Acceleration	Accelerometer	- Test Valve X-Axis	1	200
		- Test Valve Y-Axis	1	200
		- Test Valve Z-Axis	1	200
G. Test Valve Position	LVDT	- Test Valve (Safety Valves only)	1	200
H. Valve Operator Input Parameters	Air Pressure or Electrical Power	- Test Valve Operator (PORVs only)	1	20
I. Valve Body Temperature	Thermocouple	- Test Valve Body	2	2
J. Test Valve Position Monitor	Acoustic	- On Test Valve on Non-interferance Basis	1	20
K. Piping Support Reaction Loads	Load Cell	- At each Piping Support Location	8	200
L. Discharge Piping Acceleration	Accelerometer	- On Discharge Piping	4	200
M. Discharge Piping Position	LVDT	- On Discharge Piping	3	200
N. Discharge Piping Strain	Strain Gages	- On Discharge Piping	3	200
O. Discharge Piping Pressure	Pressure	- At Elbows in Discharge Piping	3	20
P. Discharge Piping Wall Temperature	Thermocuple	- At Strain Gage Locations	3	2

NOTES:

1. Does not include facility process instrumentation.

TABLE 2

SAFETY VALVE TEST MATRIX

TEST VALVE	INLET PIPING	FLUID CONDITIONS									REMARKS
		INITIAL ACCUMULATOR CONDITIONS			TRANSIENT CONDITIONS						
		P_0 (PSIA)	T_0 (°F)	FLUIDS	SET OR ACTUATION P (PSIA)	P RAMP RATE (PSI/SEC)	REQUIRED PEAK P (PSIA)	RE-SEAT P (PSIA)	TRANSIENT DESCRIPTION	BACK PRESSURE (PSIA)	
Safety Valves (spring-loaded types) • Crosby HB-BP-86 • Dresser 31739A • Dresser 31709NA	1. Straight, vertical inlet, 2-3 feet long) AND 2. Water Seal Arrangement	2400	660	Steam	2500	~200 (1) and ~15 (2)	2600-2650	(3)	Steam Flow, See Figure 1	100 and 500	15 Tests
		2400	650	Water	2500	~15	(4)	(3)	Water Flow, See Figure 1 (5), (6)	100 and 500	12 Tests
		2400	550	Water	2500	~15	(4)	(3)	Water Flow, See Figure 1 (5)	100	6 Tests
		2400	450	Water	2500	~15	(4)	(3)	Water Flow, See Figure 1 (5)	100	6 Tests
Safety Valves (pilot-operated type) • Target Rock 69C	Water Seal Arrangement	2400	660	Steam	2500	~200 (1) and ~15 (2)	2600-2650	(3)	Steam Flow, See Figure 1	100 and 500	3 Tests
		2400	650	Water	2500	~15	(4)	(3)	Water Flow, See Figure 1 (5),(6)	100 and 500	2 Tests
		2400	550	Water	2500	~15	(4)	(3)	Water Flow, See Figure 1 (5)	100	1 Test
		2400	450	Water	2500	~15	(4)	(3)	Water Flow, See Figure 1 (5)	100	1 Test 46 Tests

NOTE
(1) Actual ramp rate will depend on the capabilities of the test facility and the capacity of the test valve.
(2) These low pressurization rate tests should be performed for only one inlet piping configuration (Configuration 1 where two are specified) and for the low back pressure condition.
(3) Re-seat pressure will not be directly controlled. Valves will be set to achieve a nominal blowdown of 5% (about 125 psi).
(4) Peak pressure will not be controlled but will depend on the valve characteristics under water flow conditions.
(5) These are fixed-flow tests with a liquid flow rate of approximately 1000 gpm. It is possible that repetitive valve actuations will occur during these tests.
(6) The higher (500 psia) back pressure tests will include an initial steam flow period followed by a transition to subcooled water flow.

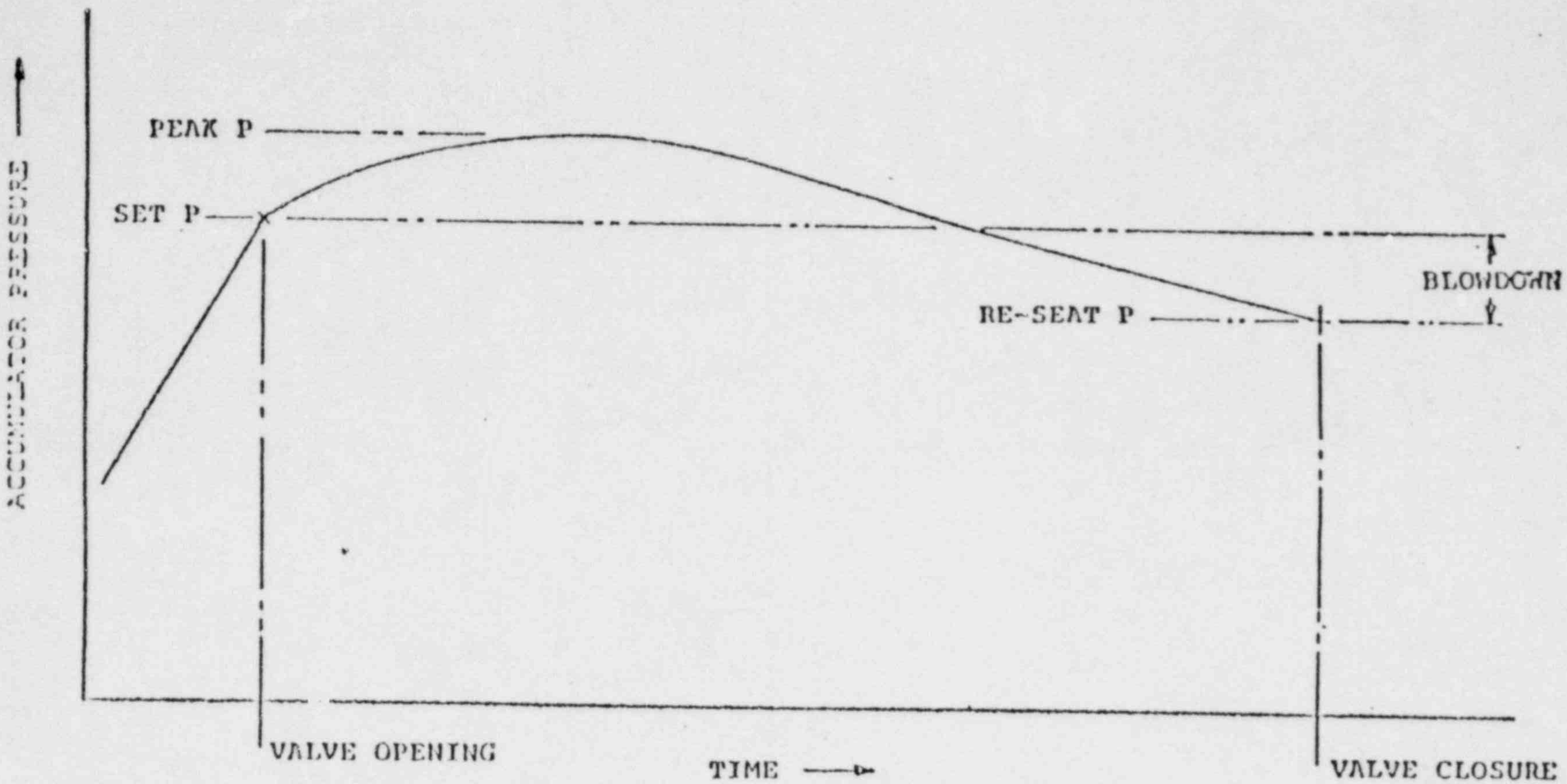
TABLE 2 (continued)

RELIEF VALVE TEST MATRIX

TEST VALVE	INLET PIPING	FLUID CONDITIONS: INITIAL ACCUMULATOR CONDITIONS: P_0 (PSIA)	T_0 (^oF)	FLUIDS	TRANSIENT CONDITIONS: SET OR ACTUATION P (PSIA)	P RAMP RATE (PSI/SEC)	REQUIRED PEAK P (PSIA)	RE-SEAT P (PSIA)	TRANSIENT DESCRIPTION	BACK PRESSURE (PSIA)	REMARKS
C. PORVs (Solenoid Pilot-Operated)	Vertical Configuration	2700	680	Steam	2700	(1)	2700	2300	Steam Flow, See Figure V-2	100 and 500	4 Tests
• Crosby HPV-SN		2700	650	Water	2700	(1)	2700	2300	Water Flow, See Figure V-2(2)	100 and 500	4 Tests
• Dresser 31533VX-30		2700	550	Water	2700	(1)	2700	2300	Water Flow, See Figure V-2(2)	100	2 Tests
		2700	450	Water	2700	(1)	2700	2300	Water Flow, See Figure V-2 (2)	100	2 Tests
		500	467	Steam	500	(1)	500	400	Steam Flow, See Figure V-2	100	2 Tests
D. PORVs (Air-Operated Globe Valve Type)	Horizontal Configuration	2700	680	Steam	2700	(1)	2700	2300	Steam Flow, See Figure V-2	100 and 500	8 Tests
• Control Components 3" Drag		2700	650	Water	2700	(1)	2700	2300	Water Flow, See Figure V-2(2)	100 and 500	8 Tests
• Copes-Vulcan 3" - 1500		2700	550	Water	2700	(1)	2700	2300	Water Flow, See Figure V-2(2)	100	4 Tests
• Fisher Controls SS-103-SS-95		2700	450	Water	2700	(1)	2700	2300	Water Flow, See Figure V-2 (2)	100	4 Tests
• Masoneilan		500	300	Water	500	(1)	500	400	Water Flow, See Figure V-2 (2)	100	4 Tests 42 Tests
										TOTAL TESTS	88

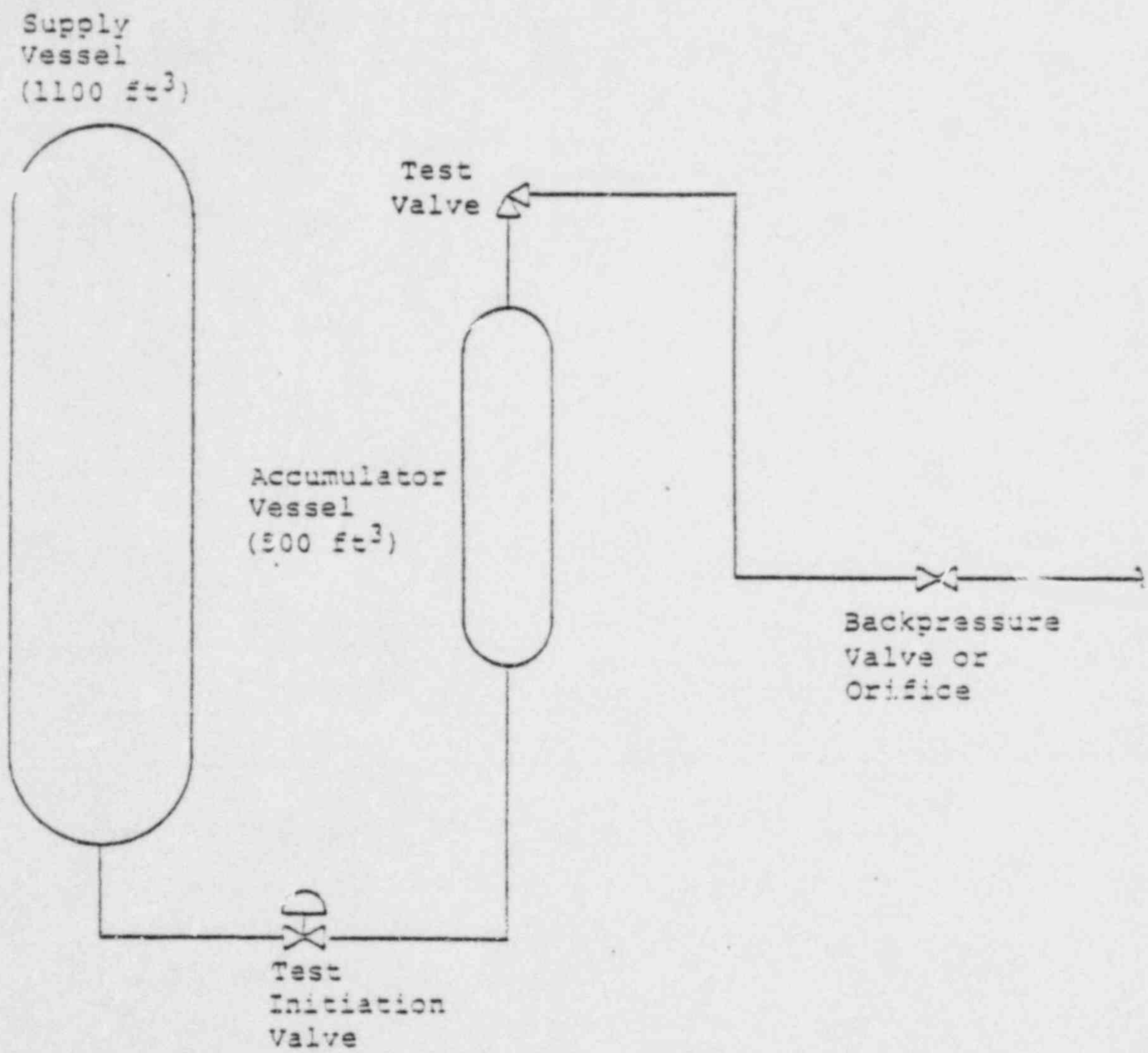
NOTE (1) This test will be initiated by electrically actuating the PORV; therefore, the pressure ramp rate will be zero.

(2) These are liquid-flow tests with a liquid flow rate of approximately 1000 gpm.



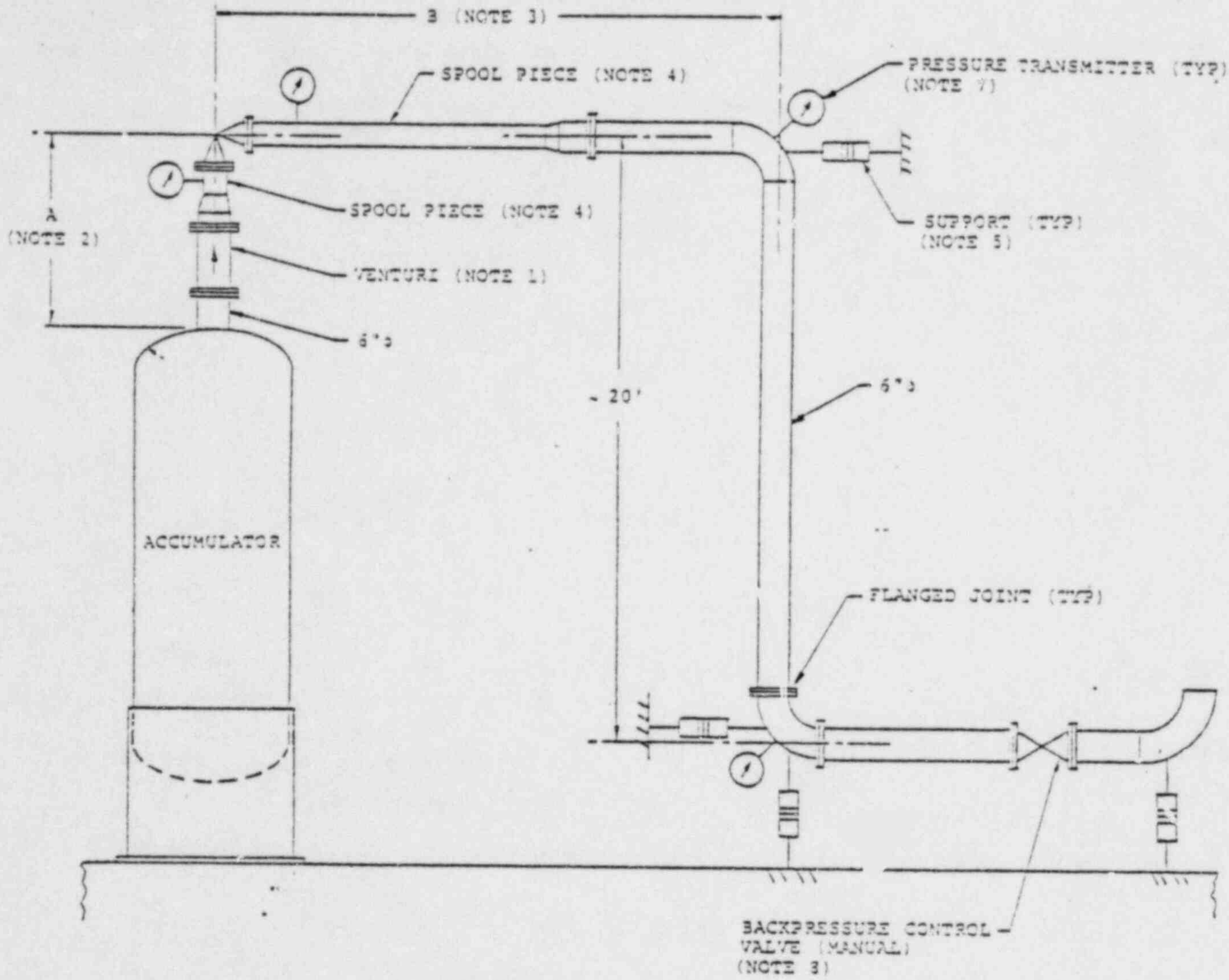
FLUID TRANSIENT CONDITIONS FOR TYPICAL
SAFETY AND RELIEF VALVE (STEAM OR WATER) TESTS

FIGURE 1



SIMPLIFIED SCHEMATIC
OF
CE FACILITY

Figure 2



• SEE SHEET 2 FOR NOTES

<u>CONFIGURATION A</u>

<u>FOR SHORT, VERTICAL, DRY INLET TO SAFETY VALVES</u>

FIGURE 3

NOTES to Figure 3

1. ASME type venturi

2. Length "A" to be as short as possible while accommodating the different safety valve inlet, outlet, and loop seal (see Figure 2) geometries.

3. Length "B" to be within 4 to 8 feet depending on the facility constraints.

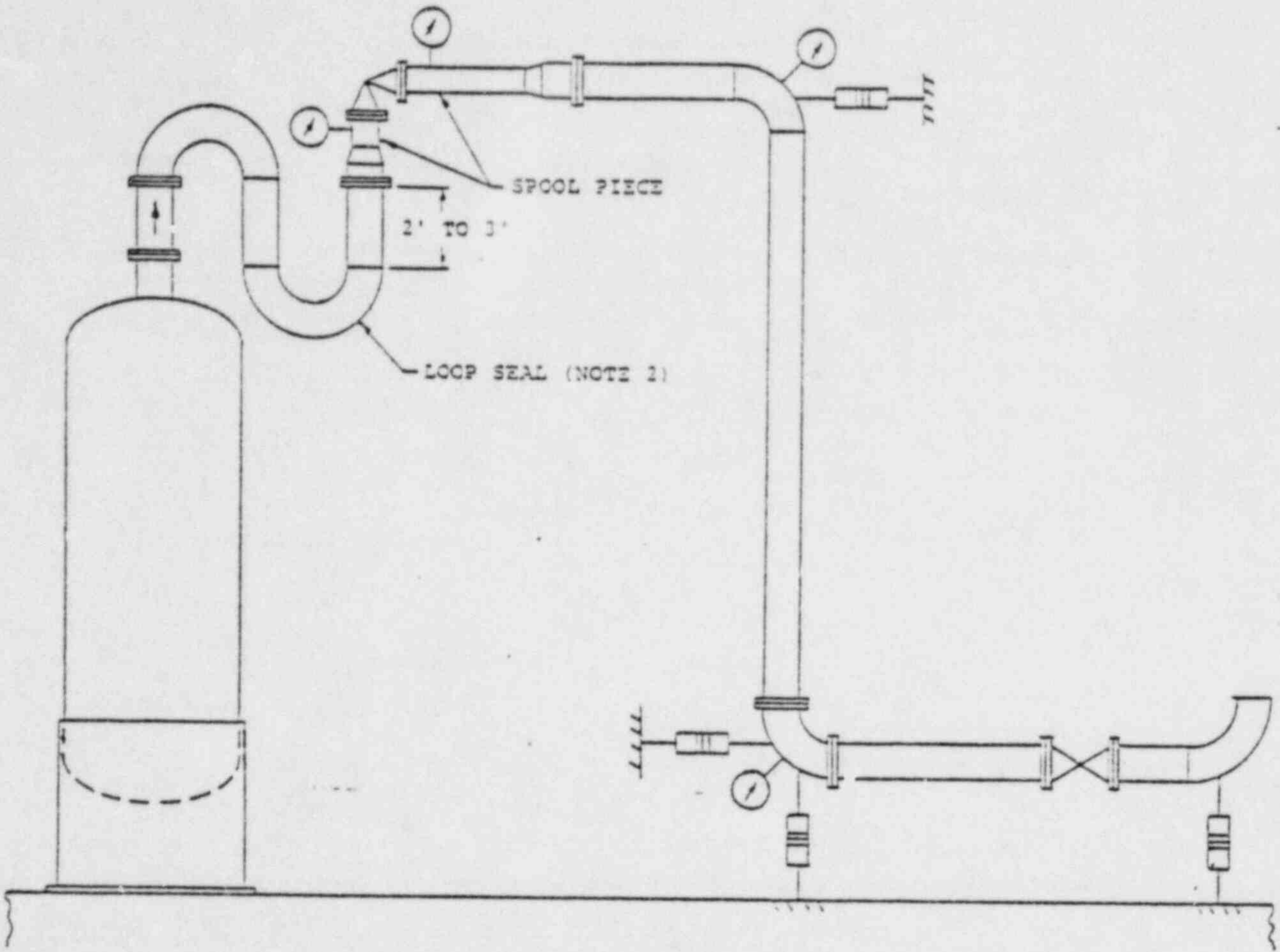
4. The spool piece lengths and diameters should be consistent with the valve dimensions and lengths "A" and "B".

5. The piping support types are to be determined by the contractor from piping flexibility analyses. If necessary, an expansion joint may be used in length B.

6. The piping supports should include load cells for measuring transient reaction forces.

7. One pressure sensor is required at the discharge of the safety valve to measure backpressure. Two pressure sensors are required at the piping elbows for measuring inlet pressure. (Sensor locations shown are preliminary).

8. An orifice can be used in place of the backpressure control valve if desired.



NOTES

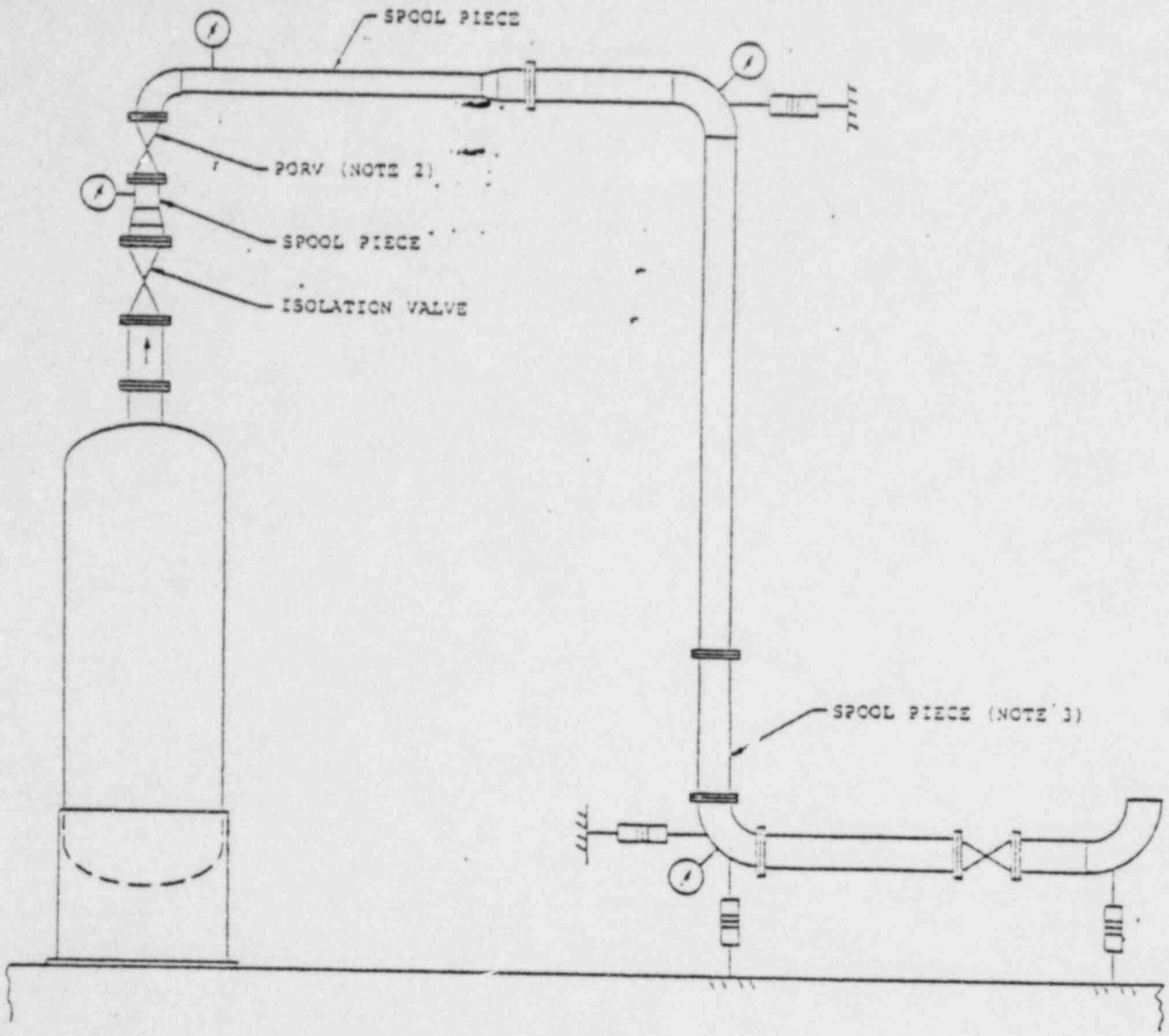
1. PIPING, PRESSURE SENSORS, SUPPORTS, VENTURI, ETC., ARE THE SAME AS THAT SHOWN IN CONFIGURATION A (FIGURE 1), EXCEPT FOR THE LOOP SEAL AT THE SAFETY VALVE INLET AND THE SPOOL PIECES.

2. THE LOOP SEAL SHOULD BE CONSTRUCTED OF FOUR 6" LONG RADIUS ELBOWS WITH 2' TO 3' STRAIGHT VERTICAL SECTIONS AS SHOWN.

CONFIGURATION B

FOR LOOP SEALS FOR SAFETY VALVES

FIGURE 4



NOTES

1. PIPING, PRESSURE GAGES, SUPPORTS, VENTURI, ETC., ARE THE SAME AS THAT SHOWN IN CONFIGURATION A (FIGURE 1), EXCEPT FOR THE ISOLATION VALVE AT THE PORV INLET.

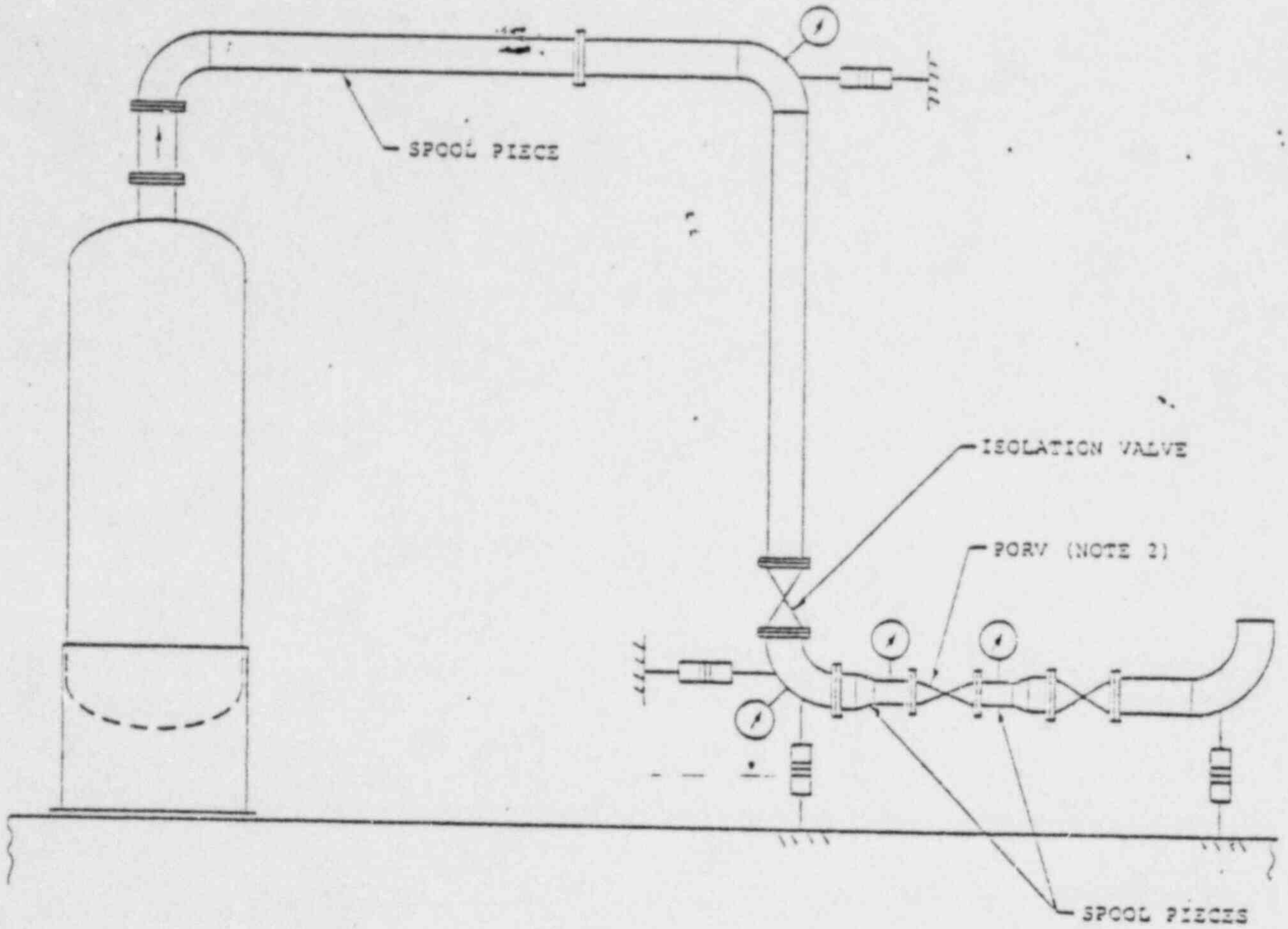
2. A 90 DEGREE LONG RADIUS ELBOW SHOULD BE USED AT THE INLET OF A PORV MOUNTED HORIZONTALLY.

3. A SPOOL PIECE MAY BE REQUIRED IN THE VERTICAL OUTLET PIPING TO ACCOUNT FOR THE ADDED HEIGHT OF THE ISOLATION VALVE AND 90° ELBOW AT PORV DISCHARGE.

CONFIGURATION C

SHORT VERTICAL DRY INLET FOR PORV

FIGURE 5



NOTES

1. BASIC PIPING DIMENSIONS, PRESSURE SENSORS, SUPPORTS, VENTURI, ETC., ARE THE SAME AS THAT SHOWN IN CONFIGURATION A (FIGURE 1), EXCEPT FOR THE ISOLATION VALVE AND SPOOL PIECES.

2. 90° ELBOWS WILL BE REQUIRED AT THE INLETS AND OUTLETS OF PORV'S THAT MUST BE MOUNTED VERTICALLY.

CONFIGURATION D

LONG INLET FOR PORV'S

FIGURE 6

APPENDIX D

SUMMARY OF FOREIGN VALVE TEST PROGRAMS

Germany, France and Japan are presently conducting valve test programs which could provide applicable input to the test program defined in this document. These programs are of interest since they could provide:

1. Experience with valve test facility design, operation and instrumentation.

2. Safety and relief valve system data to validate analytical methods.

Utilizing foreign experience with regard to safety and relief valve testing is highly desirable in order to identify and minimize potential problem areas which might otherwise have a significant impact on the PWR Safety and Relief Valve test program schedule. Efforts to explore cooperative arrangements with the organizations responsible for these test programs are presently underway by EPRI.

- German Programs
  - BMFT/RS 240 Program

    The BMFT/RS 240 test program is being performed by KWU at Erlangen and Karlstein and is sponsored by the Federal Minister of Research and Technology. The program is entitled "Investigation on the Functioning of the Pressurizer Safety Valves and the Relief Tank during Blowdown of Hot Pressurized Water".

Tests with saturated steam and subcooled liquid discharge have been performed. Valve performance tests involving the transition from steam to hot pressurized water have yet to be run.

- HDR Program

  In conjunction with the planned HDR blowdown tests, tests have been performed on steam line isolation valves and feedwater check valves of two different sizes. Extensive thermal hydraulic and structural measurements were made during these valve tests. While these experiments have not involved relief valves, they are important since the data may be useful in the verification of analysis methods.

° French Programs

- EDF Program

  EDF is performing a test program on a prototypical spring-loaded safety valve. Quasi-steady state tests were performed in which the valve was mechanically held in the full-open position and subjected to subcooled liquid discharge (p = 1700 psi, T = 620°F).

  The facility is limited by its maximum pressure rating of 1700 psi but there are plans to upgrade its capability to 2900 psi. Negotiations with EDF are underway to exchange valve test information.

- Framatome Program

  Framatome is planning a safety/relief valve system test during hot functionals of a contract Programme 1 PWR during March, 1981, and has invited EPRI to participate in this program. The specific objectives of these tests are to determine forces on piping and supports during discharge and to investigate condensation phenomena in the relief tank during a "long" duration relief valve discharge (approximately one minute). One test will include sequential openings of two of the three safety valves during a short (five-second) duration discharge.

° Japanese Programs

The Japanese are planning to perform BWR and PWR Safety/Relief Valve Tests at the Nuclear Power Engineering Test Center located at Isogo, Japan (near Yokahama). The valve test facility is driven by a boiler capable of providing 15t/hr of superheated steam at 175 bar and 384°C.

The extent of PWR safety/relief valve tests and the actual test conditions to be utilized are not known at this time. The test facility is in full operation and a significant number and type of nuclear valves are planned to be tested. Efforts will be pursued to develop a technical exchange.