

Revision 1

EPRI PWR SAFETY AND RELIEF VALVE TEST PROGRAM
GUIDE FOR APPLICATION OF VALVE TEST PROGRAM
RESULTS TO PLANT-SPECIFIC EVALUATIONS

INTERIM REPORT, MARCH 1982
(RESEARCH PROJECT V102)

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PREFACE

This guide has been developed to assist participating PWR Utilities in determining the applicability of the various test results from the EPRI program for their plant-specific evaluations. The overall key to using the guide is to most closely match the valve/piping configurations tested by EPRI with actual plant installations. In following this approach care should be taken not to overlook the results of any test for possible applicability, i.e., each test conducted on a representative valve type may have some generic or indirect applicability. However, the closer the tie between specific EPRI tests and the plant installation, the more direct the applicability of the results. It is expected that the approach developed in this guide will be useful for virtually all of the plant evaluations.

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I. INTRODUCTION

A. Purpose of the Application Guide

The purpose of the application guide is to provide a procedure for utilities to follow in preparing plant-specific submittals in response to NUREG-0737 ("Clarification of TMI Action Plan Requirements") Section II.D.1-A, Requirements. Specifically, NUREG-0737 requires the following:

1. An evaluation of safety and relief valve functionality for plant-specific operating and accident conditions.
2. An evaluation of piping and support adequacy for plant-specific conditions.

In preparing the application guide, it was assumed that the utilities would obtain assistance from the valve manufacturers and NSSS vendors in performing the required evaluations. Specifically, it was assumed that:

1. The utilities (with possible assistance from architect-engineers or other piping designers) will perform the evaluations of piping and support adequacy.
2. The valve manufacturers will perform the evaluations of valve performance.

3. The NSSS vendors will perform the evaluations of overpressure protection system performance.
4. The utilites will coordinate the overall evaluation effort and prepare the plant-specific submittal to the NRC.

The delineation of responsibilities outlined above is based on impressions gained throughout the program regarding which organization(s) was probably best suited to accomplish a particular task. It is recognized that some utilities may elect to perform more or fewer tasks than assigned in this guide. The important point is that the guide highlights the tasks that need to be done and assigns them to an appropriate organization. The participating utility has final control over both the scope of work details and the organization assigned.

The Application Guide is based on directly using test results from the EPRI program in the plant-specific evaluations. Thus, in order to use the guide, one must establish the one (or more) valve/piping configuration tested by EPRI which most closely matches the plant installation. It is expected this approach will be useful for virtually all of the plant evaluations. The guide assists in defining the limits of applicability of the EPRI data.

B. Contents of the Guide

The contents of the application guide are summarized in the following:

° Section II -- Procedure to be Followed in Plant-Specific Evaluations

A. Flow Charts for the Evaluations

This section describes the overall approach to be followed in performing the evaluations of valve performance and piping/support adequacy.

B. Workscopes for the Evaluations

This section discusses the workscopes for the evaluations to be performed by the utilities, the valve manufacturers, the NSSS vendors and EPRI.

° Section III -- Evaluation of Test Results for Plant-Specific Conditions

A. Identification of Pertinent Plant Parameters

This section identifies the pertinent plant-specific safety and relief valve, inlet piping, discharge piping and valve actuation transient parameters to be assembled by the utilities for use in the evaluations.

B. Procedures for Evaluation of Test Results

This section provides the procedures to be used in performing the evaluations of valve performance and piping/support adequacy. For the valve performance evaluation, it provides guidelines for identifying applicable valve tests, a table to be used by the valve manufacturer to document valve performance characteristics, and a suggested set of acceptance criteria for valve performance. For the piping/support adequacy evaluation, it provides suggested guidelines for the evaluation and a suggested set of structural acceptance criteria.

C. Identification of Potential Problem Areas and Possible Alternatives to Address Undesirable Valve Performance

This section provides a listing of potential problem areas regarding valve performance and piping/support adequacy identified based on the results of the EPRI Safety and Relief Valve Test Program. It also discusses possible alternatives to be considered by the utilities to address undesirable valve performance features.

• Section IV -- Suggested Format for July 1, 1982 Plant-Specific Submittal

This section of the guide provides a suggested format for the July 1, 1982 plant-specific submittal to the NRC.

° Section V -- References

This section provides a listing of the various EPRI Program reports to be used by the utilities in performing the plant-specific evaluations.

° Section VI -- Appendices

A. Procedure for Calculation of Valve Back Pressure

This appendix outlines a suggested procedure and guidelines for the calculation of valve back pressure.

B. Procedure for Calculation of Inlet Piping Pressure Effects

This appendix provides a suggested procedure and guidelines for the calculation of inlet piping pressure effects.

C. Procedure for Verification of Alternative Methods to be used in Evaluation of Piping/Support Adequacy

This appendix provides a suggested procedure to verify the adequacy of the alternative methods to be used to evaluate the structural adequacy of the piping and supports.

D. Procedure for Assessment of Applicability of Specific EPRI Safety Valve Tests

This appendix outlines a procedure to assist in determining the applicability of EPRI safety valve tests to specific plant evaluations.

E. Load Combinations and Acceptance Criteria for
the Safety and Relief Valve Piping Evaluation

This section provides recommended load combinations and acceptance criteria to be used by the utilities in evaluating the adequacy of the safety and relief valve piping and supports.

II. PROCEDURE TO BE FOLLOWED IN PLANT-SPECIFIC EVALUATIONS

A. Flow Charts for the Evaluations

1. Evaluation of Valve Performance

- Safety Valves

The flow chart provided in Table II-1 illustrates the overall procedure to be followed in performing the evaluations of safety valve performance. The input for the evaluations consists of:

- ° EPRI valve program reports as listed in Section V of this guide.
- ° List of pertinent plant parameters as identified in Table III-1.

The evaluations to be performed consist of the following:

- ° An evaluation of test results by the valve manufacturer to identify any potential problem areas regarding valve performance.
- ° An evaluation by the NSSS vendor to identify any potential problem areas regarding overpressure protection system performance.

- ° An evaluation by the utility of possible alternatives to address undesirable valve performance features.

The output from the evaluations consists of:

- ° A report for submittal to the NRC which documents the results of the plant-specific evaluations. This report would address the selection and schedule for implementation by the utility of any required modifications to the valves and/or the overpressure protection system parameters.

Although not shown specifically in the flow chart, a significant amount of interaction is expected to be required among the utility, valve manufacturer and NSSS vendor during the course of the evaluations. Also, it is expected that the utilities will assume the responsibility for coordinating the overall evaluation effort.

- Relief Valves

The evaluation of relief valve performance should also be performed following the procedure shown in Table II-1. However, this evaluation should be more straightforward than the safety valve performance evaluation and it is expected that the utilities would perform the bulk of the evaluation.

2. Evaluation of Piping/Support Adequacy

The flow chart provided in Table II-2 illustrates the overall procedure to be followed in performing the evaluations of piping/support adequacy. The input for the evaluations consists of:

- ° Verified computer codes for determination of hydraulic loads and EPRI valve program reports as listed in Section V of this guide.
- ° List of pertinent plant parameters as identified in Table III-1.

The evaluations to be performed by the utility consist of the following:

- ° An evaluation of the piping stresses and support loads using the EPRI-provided codes or other method which has been verified by comparison of predictions with EPRI test data provided in Reference 7.
- ° A comparison of calculated piping stresses and support loads with allowables and identification of any potential problem areas.

- ° An evaluation of possible alternatives to address potential piping/support problem areas.

The output of the evaluations consists of a report for submittal to the NRC which provides the results of the plant-specific evaluations. The report may include, if required, the selection and implementation schedule of modifications to the piping and supports.

B. Workscopes for the Evaluations

Tables II-3 through II-8 summarize the workscopes for the various evaluations to be performed by the utility, the valve manufacturer, the NSSS vendor and EPRI. The tables are identified as follows:

Table	Organization	Evaluation
II-3	Utility	Safety and Relief Valve Performance
II-4	Utility	Piping/Support Adequacy
II-5	Valve Manufacturer	Safety Valve Performance
II-6	Valve Manufacturer	Relief Valve Performance
II-7	NSS Vendor	Safety and Relief Valve Performance
II-8	EPRI	Valve Performance and Piping/Support Adequacy

TABLE II-1

Revision 1

APPLICATION OF VALVE TEST RESULTS TO PLANT - SPECIFIC EVALUATIONS OF VALVE PERFORMANCE

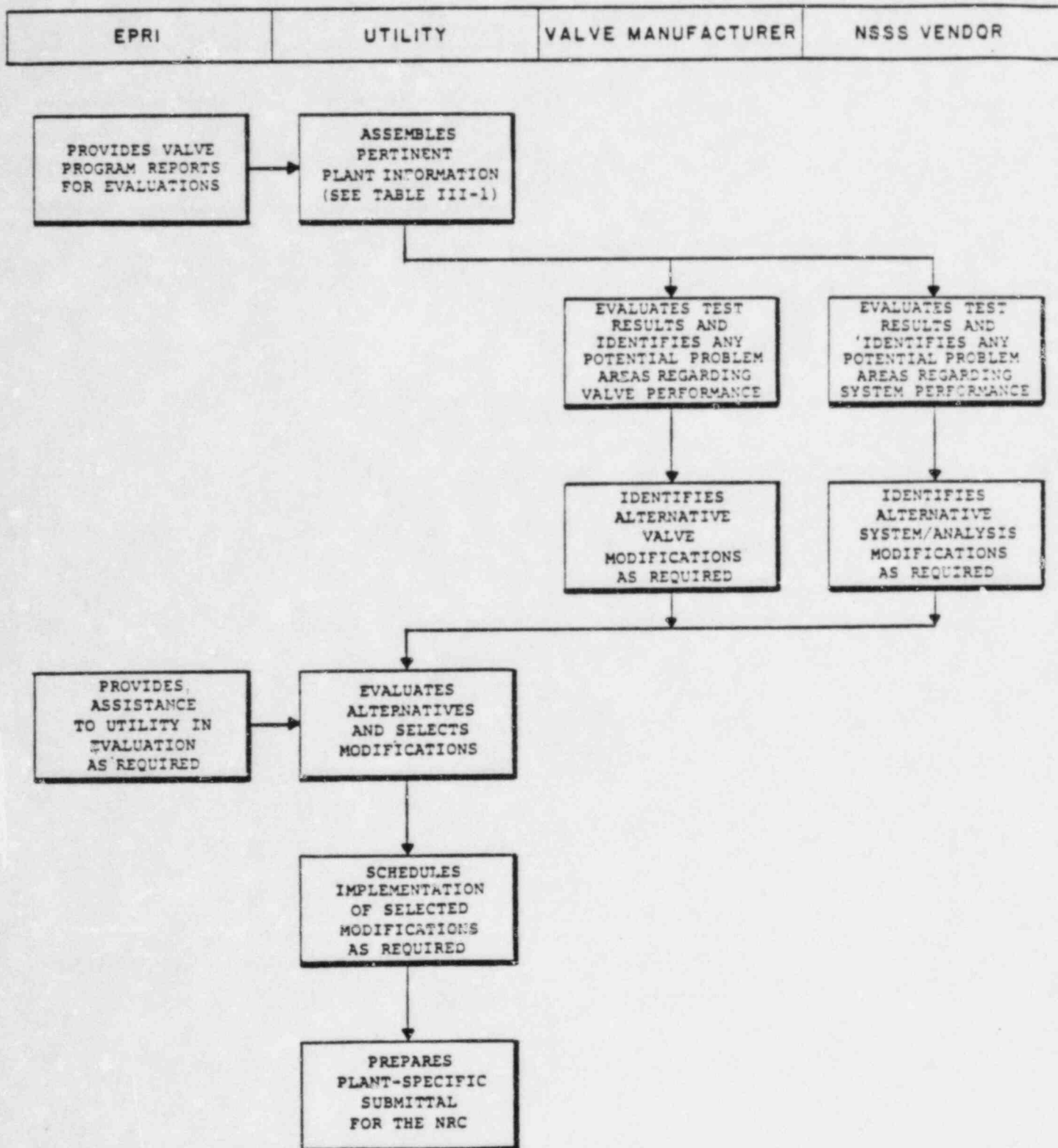


TABLE II-2

APPLICATION OF VALVE TEST RESULTS TO PLANT - SPECIFIC
EVALUATIONS OF PIPING ADEQUACY

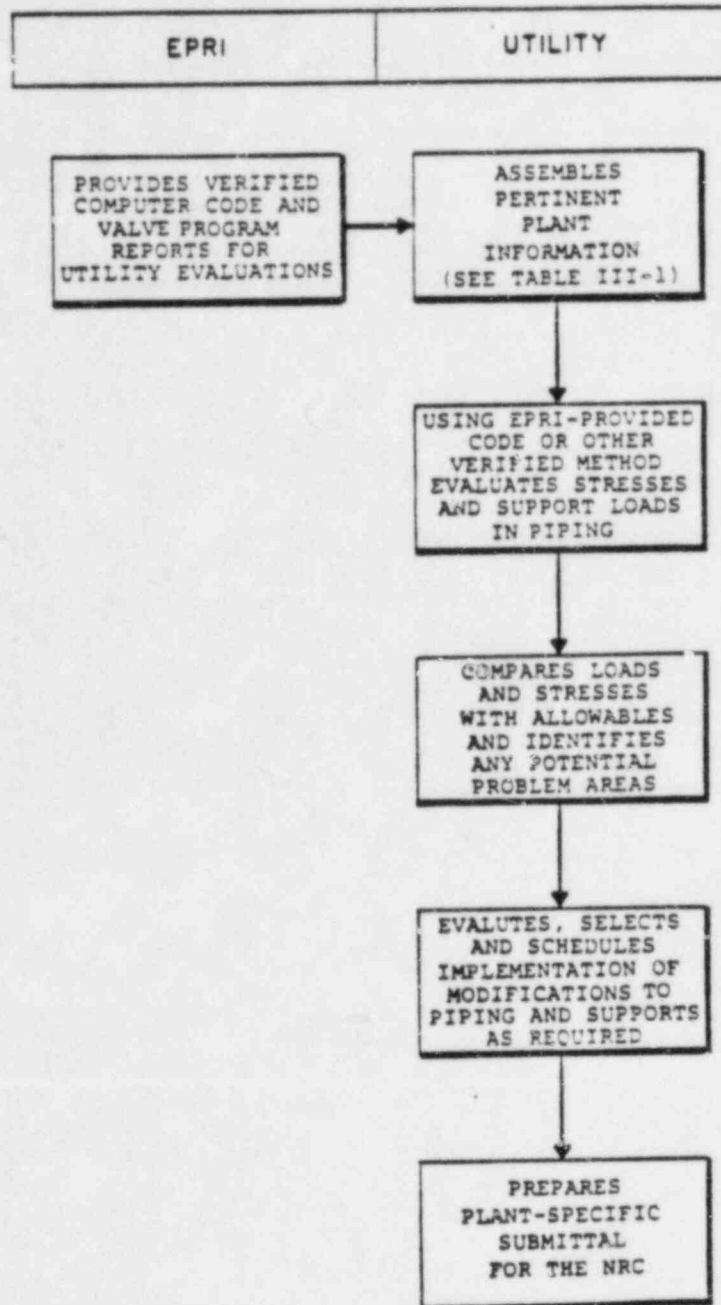


TABLE II-3
WORKSCOPE FOR UTILITY EVALUATION OF
SAFETY AND RELIEF VALVE PERFORMANCE

The utility will perform the following:

1. Identify pertinent plant information listed in Table III-1, including:
 - Valve parameters
 - Inlet piping parameters
 - Discharge piping parameters
 - Valve actuation transient parameters
2. Evaluate alternative modifications identified by valve manufacturer and/or NSSS vendor and select modifications for implementation.
3. Schedule implementation of selected modifications to valves.
4. Prepare plant-specific submittal for the NRC.

TABLE II-4
WORKSCOPE FOR UTILITY EVALUATIONS
OF PIPING/SUPPORT ADEQUACY

The utility will perform the following:

1. Identify pertinent plant information listed in Table III-1, including:
 - Valve parameters
 - Inlet piping parameters
 - Discharge piping parameters
 - Valve actuation transient parameters
2. Using EPRI-provided code or other verified (by comparison with valve test results) method, evaluate stresses and support loads in inlet and discharge piping.
3. Compare loads and stresses with allowable values and identify any potential problem areas.
4. Evaluate, select and schedule implementation of modifications to piping and supports as required.
5. Prepare plant-specific submittal for the NRC.

TABLE II-5
WORKSCOPE FOR VALVE
MANUFACTURER EVALUATION
OF SAFETY VALVE PERFORMANCE

A. Bases for Evaluation

The following will be provided to the valve manufacturer for his use in the evaluations:

1. Applicable EPRI test program outputs.
2. Plant information listed in Table III-1

B. Scope of Evaluation

The valve manufacturer will perform the following:

1. Define performance for as-installed valve ring settings based on:
 - ° EPRI test data
 - ° Valve manufacturer's test data
 - ° Valve manufacturer's supporting analysis

The evaluation should:

- ° Determine which fluid conditions result in stable or unstable valve performance.
 - ° Establish valve performance characteristics (e.g., blowdown, lift, flow opening time, etc.).
2. Define performance for optimal valve ring settings in accordance with the steps identified in 1 above.
 3. Recommend valve modifications to provide improved performance, if needed (e.g., to provide reduced blowdown, stable water performance, etc.).
 4. Document performance recommendations and bases for recommendations to the utilities.

TABLE II-6
WORKSCOPE FOR VALVE MANUFACTURER
EVALUATIONS OF RELIEF VALVE PERFORMANCE

A. Bases for Evaluation

The following will be provided to the valve manufacturer for his use in the evaluations:

1. Applicable EPRI test program outputs.
2. Plant information listed in Table III-1

B. Scope of Evaluation

The valve manufacturer will perform the following:

1. Establish valve performance characteristics
(e.g., opening time, flow, closing time)
2. Recommended valve modifications to provide improved performance, if needed.
3. Document performance recommendations and bases for recommendations to the utilities.

TABLE II-7
WORKSCOPE FOR NSSS VENDOR EVALUATION OF
SAFETY AND RELIEF VALVE PERFORMANCE

A. Bases for Evaluation

The following will be provided to the NSSS vendor for his use in the evaluations:

1. Applicable EPRI test program outputs.
2. Plant information listed in Table III-1.
3. Valve performance characteristics (e.g., blowdown, lift, flow, opening time, etc.), as established by the valve manufacturer.

B. Scope of Evaluation

The NSSS vendor will perform the following:

1. Evaluate test results and document system acceptability or identify any potential problem areas regarding NSSS overpressure protection system performance.
2. If potential problems are identified:
 - ° Identify alternative modifications to NSSS overpressure protection system and/or overpressure transient analysis parameters to resolve unacceptable performance.
 - ° Concur with system/analysis modifications selected by utility for implementation.
 - ° Prepare report which justifies acceptability of system/analysis modifications selected for implementation.

TABLE II-8
WORKSCOPE FOR EPRI EVALUATIONS

A. Valve Performance

1. Provide valve program reports for utility evaluations.
2. Provide on-going assistance to utilities in the understanding and use of program outputs as required.

B. Piping/Support Adequacy

Provide verified computer code and valve program reports for utility evaluations of inlet and discharge piping and support adequacy. The code provided by EPRI is to be used for the calculation of the time-dependent hydraulic loads applied by the fluid on the piping.

III. EVALUATION OF TEST RESULTS FOR
PLANT-SPECIFIC CONDITIONS

A. Identification of Pertinent Plant Parameters

A list of pertinent plant parameters to be identified by the utility is provided in Table III-1. Possible sources to be used by the utility in compiling the required information are listed below:

1. Plant Final Safety Analysis Report/Cold Overpressurization Analysis Report
2. Plant Technical Specifications
3. Plant installation drawings and system isometrics
4. Valve Documentation and Nameplate Information
5. Initial valve manufacturer's test data and periodic set pressure verification test data.

In addition, the EPRI valve program reports (see Section V) and the appendices to this guide should be useful as follows:

- ° The test conditions justification report (Reference 3) and plant conditions justification report (References 4, 5 and 6) should be useful in assembling the valve actuation transient information.
- ° Appendix A provides a procedure to be used for the calculation of valve back pressure.
- ° Appendix B provides a procedure to be used to calculate the inlet piping pressure drop associated with valve opening and pressure rise associated with valve closing.

B. Procedures for Evaluation of Test Results

1. Safety Valve Performance and Associated Piping/Support Adequacy

The procedure to be used to evaluate safety valve performance for plant-specific conditions is as follows:

° Step 1

The utility provides the assembled plant information (Table III-1) and the applicable EPRI valve test program output to both the valve manufacturer and the NSSS vendor.

° Step 2

The valve manufacturer identifies the specific EPRI tests which are applicable for the plant-specific safety valve evaluation being performed. An outline for conducting this type of evaluation is provided in Appendix D to this report.

° Step 3

Based on the information provided by the utility (see Step 1 above) and the valve manufacturer's own test data and supporting analyses, the valve manufacturer determines the valve performance characteristics and completes the performance summary sheet provided in Table III-2 for both as-installed and optimal ring settings.

° Step 4

The utility performs an evaluation of safety valve inlet and discharge piping stresses and piping support and valve loads.

° Step 5

The NSSS vendor compares the valve performance characteristics listed in Table III-2 with the valve characteristics assumed in the FSAR (or other design) overpressure protection system analyses and identifies any conditions for which the actual and assumed valve performance characteristics are not consistent (see Table III-3 for performance characteristics to be considered). Where not consistent, the NSSS vendor should judge the acceptability of the deviation and provide the basis for his judgment.

° Step 6

The utility compares the safety valve piping/support loads and stresses with the allowable values and identifies any conditions for which the allowable values are exceeded (see Table III-3 for definition of piping and support allowable loads and stresses).

° Step 7

The utility (with assistance from the valve manufacturer and NSSS vendor as required) identifies any conditions for which acceptable valve performance is not obtained. The utility then evaluates

possible alternatives which could provide acceptable valve performance and selects any needed modifications to be made to the valves or piping.

° Step 8

The utility, valve manufacturer and NSSS vendor prepare reports which document their evaluations and justify the acceptability of any modifications selected for implementation.

2. Relief Valve Performance and Associated Piping/Support Adequacy

The procedure to be used to evaluate relief valve performance for plant-specific conditions is outlined in the following. It is noted that these evaluations should be straightforward and it is expected that the utility could perform the bulk of the evaluations.

° Step 1

The utility assembles the plant information (Table III-1) and the applicable EPRI valve test program outputs.

° Step 2

Based on the plant information and the EPRI valve test data, the valve manufacturer (or utility) determines the valve performance characteristics and completes the performance summary sheet provided in Table III-4. This evaluation should consider any differences in the air and/or electrical supply and for pilot-operated valves the pilot vent discharge tubing for that installed in plants compared to that tested.

° Step 3

The utility performs an evaluation of relief valve inlet and discharge piping stresses and piping support and valve loads.

° Step 4

The NSSS vendor (or utility) compares the performance characteristics listed in Table III-4 with the valve characteristics assumed in the cold overpressurization analyses and identifies any conditions for which the actual and assumed valve performance characteristics are not consistent (see Table III-3 for performance characteristics to be considered).

° Step 5

The utility compares the relief valve piping/support loads and stresses with the allowable values and identifies any conditions for which the allowable values are exceeded (see Table III-3 for definition of piping and support allowable loads and stresses).

° Step 6

The utility identifies any conditions for which acceptable valve performance is not obtained, and then evaluates possible alternatives

which could provide acceptable valve performance and selects any needed modifications.

° Step 7

The utility, valve manufacturer, and NSSS vendor prepare reports which document their evaluations and justify the acceptability of any modifications selected for implementation.

C. Identification of Potential Problem Areas and Possible Alternatives to Address Undesirable Valve Performance

Based on the results of the EPRI valve tests, it is apparent that there are some plant conditions which could result in valve performance characteristics which are not within acceptable limits (as currently defined). As discussed in previous sections, the first step in addressing these potential concerns is to perform analyses to attempt to demonstrate that the observed valve performance can be accommodated in the plant. Should these efforts be unsuccessful, several alternatives are available to resolve these potential problems. A list of potential problem areas and some possible alternatives to be considered to address the undesirable valve performance is provided in Table III-5. It should be noted that this list is not intended to be complete, but only to serve as a checklist or starting-point for the more detailed performance evaluations to be performed by the utilities, valve manufacturers and NSSS vendors.

Table III-6 provides a general summary of the safety valve test results obtained in the EPRI program. Some considerations to be taken into account in evaluating off-normal valve performance for various conditions as noted in Table III-5 are discussed below:

- Safety Valves

1. Performance with Steam Flow

For virtually all safety valve/inlet piping combinations tested, ring settings were established in the EPRI tests which provided stable valve performance with steam inlet conditions. However, these ring settings resulted in valve blowdown outside of normally accepted limits (i.e., greater than five percent). Therefore, re-evaluation of selected NSS system overpressure transients should be performed by the NSSS vendors to show that increased valve blowdown is acceptable. Other potential alternatives would be to utilize an alternative valve or shorten the valve inlet piping so that stable performance can be obtained with reduced blowdown (i.e., near five percent).

2. Performance with Subcooled Water Flow

For some of the safety valves tested, the valves chattered with subcooled water inlet conditions.

For these cases, if the fluid conditions for a specific plant include subcooled water, the utility/NSSS vendor could show that the subcooled water can be handled by other than safety valve actuation. This could be accomplished by use of the PORVs to vent the flow (at a pressure less than the safety valve set pressure) or by operator termination of the transient. Another possible solution is to utilize an alternative valve which performs in a stable manner with subcooled water or to modify the existing valve (e.g., using an assist device) to provide stable performance.

3. Performance with Cold Loop Seals

For the tests (with the spring-loaded valves) which utilized cold loop seals at the valve, a number of undesirable performance characteristics resulted, including large pressure oscillations in the upstream piping, delayed valve opening until loop seal clearing, and high pressures and loads in the discharge piping. (Elevated temperature loop seal tests resulted in reduced piping loads.) Possible alternatives to eliminate these undesirable performance features include draining the loop seal, heating the loop seal to near saturation or utilizing an alternative valve which provides better

performance with the loop seal. However, before a decision to drain or heat loop seals is made, careful consideration should be given to the potential consequences, e.g., increased potential for valve seat degradation and resulting steam/hydrogen leakage.

- Relief Valves

Acceptable performance was obtained with most of the relief valves tested. An off-normal result obtained was delayed valve closure for two of the relief valves (Dresser Electromatic and Target Rock) with fluid conditions that result from loop seal installations. For plants which utilize these valves with loop seals, possible alternatives to consider include heating or draining of the loop seal, or utilizing an alternative valve which is less sensitive to the thermal transient. However, before a decision to drain or heat loop seals is made, careful consideration should be given to the potential consequences of such operation as noted above.

TABLE III-1
PLANT INFORMATION TO BE ASSEMBLED BY UTILITY

Following is a list of valve/piping information to be assembled by the utility for the evaluations:

1. Safety Valve Information

Number of valves
Manufacturer
Type
Size (inlet, outlet, orifice)
Steam flow capacity (rated and maximum)
Design pressure and temperature
Inlet flange rating
Discharge flange rating
Allowable applied load (should consider the applied load which resulted during testing)
Set pressure
Accumulation (specified and existing, if available)
Blowdown (specified and existing, if available)
Ring settings (specified and existing, if available)
Original valve procurement specification
Original valve quality assurance package
Maintenance documentation package for valve

2. Relief Valve Information

Number of valves
Manufacturer
Type
Size (inlet, outlet, orifice)
Steam flow capacity (actual)
Design pressure
Design temperature
Inlet flange rating
Discharge flange rating
Allowable applied load (should consider the applied loads which resulted during testing)

TABLE III-1 (Cont'd)

Opening pressure (include all settings)

Closing pressure (include all settings)

Original valve procurement specification

Original valve quality assurance package

Maintenance documentation package for valve

For air-operated valves:

- Air supply system pressure and system schematic (tubing diameter, length, configuration, etc.)

For pilot-operated valves:

- Electrical supply system voltage and current and wiring schematic
- Pilot vent path schematic (pipe diameter, length, configuration, etc.)

3. Inlet Piping Information

Design pressure

Design temperature

Configuration from pressurizer to valve (include an isometric drawing of the installation showing piping diameter, length and orientation)

Pressurizer nozzle configuration

Loop seal (include volume and temperature of water in loop seal)

Piping supports (show location on isometric and list type and capacity of individual supports in a table)

Steady-state flow pressure drop (including velocity head) ⁽¹⁾

Acoustic wave pressure amplitude⁽¹⁾

4. Discharge Piping Information

Design pressure

Design temperature

Configuration (include an isometric drawing of the installation showing piping diameter, length and orientation)

Pressurizer relief tank design pressure

Piping supports (show location on isometric and list type and capacity of individual supports in a table)

Note: (1) See Appendix B, applies to safety valves only.

TABLE III - 1 (Cont'd)

5. Valve Actuation Transient Information

- FSAR Transients

Pressure (opening, peak, closing)

Temperature

Pressurization rate at valve opening

Maximum back pressure⁽²⁾ (steam condition)

Fluid range (e.g., saturated steam, saturated water, steam to water transition, subcooled water)

Valves actuated (number and type)

- Cold Overpressure Transients⁽¹⁾

Pressure ranges (opening, peak, closing)

Corresponding temperature ranges

Pressurization rate at valve opening

Maximum back pressure⁽²⁾ (steam condition)

Fluid range

Valves actuated (number and type)

- Extended High-Pressure Injection Transients⁽¹⁾

Pressure range (opening, peak, closing)

Corresponding temperature range

Initial pressurization rate

Maximum back pressure⁽²⁾ (steam condition)

Fluid range

Valves actuated (number and type)

Notes: (1) Applies to relief valves only

(2) See Appendix A

TABLE III-2
SAFETY VALVE PERFORMANCE
SUMMARY SHEET

A. Parameters for Safety Valve Installation in Plant

The following parameters are to be tabulated for the plant installation. They are to be used to identify the tests with the representative valve/piping configuration most nearly corresponding to the plant configuration.

1. Safety Valve

- Manufacturer
- Type
- Size

2. Inlet Piping

- Piping length
- Piping diameter
- Dry or loop-seal

3. Discharge Piping

- Back pressure range (for steam actuation)

4. Inlet Piping Pressure Drop (Steam Actuation)

- Steady-state
- Acoustic (after loop seal discharge)

5. Applicable Test Numbers

(Selected by comparing preceding information with EPRI test data)

6. Valve Ring Settings

Ring	Ring Settings	
	As-Installed	Optimal
Upper		
Middle		
Lower		

TABLE III-2 (Cont'd)

B. Valve Performance Summary

The following valve performance characteristics are to be determined from the data for the applicable tests for both as-installed and optimal ring settings.

1. Behavior Mode

Fluid Condition	Stable	Chatter	Other
Saturated steam			
Loop seal			
Transition			
Water			
- 650°F			
- 550°F			
- 400°F			

2. Performance Characteristics*

Fluid Condition	Opening Pressure (psia)	Opening Time (sec)	Flow Capacity (lb/sec)	Closing Pressure (psia)
Saturated steam				
Loop seal				
Transition				
Water				
- 650°F				
- 550°F				
- 400°F				

* In addition, determine maximum back pressure for saturated steam condition.

TABLE III-3
DEFINITION OF ACCEPTABLE PERFORMANCE FOR
SAFETY AND RELIEF VALVES AND
INLET AND DISCHARGE PIPING

Following is a definition of acceptable performance for safety and relief valves and inlet and discharge piping:

A. Safety Valves

1. Valves open and close in a stable manner. (A minimum amount of valve chatter or flutter is permitted provided no change in critical valve dimensions or wear of seating surfaces results.) See Note (1).
2. Valve performance characteristics are consistent with FSAR (or other design) overpressure analysis assumptions, including:
 - opening pressure
 - opening time
 - flow capacity
 - closing pressure (i.e., blowdown)

B. Relief Valves

Valve performance characteristics are consistent with cold overpressurization analysis assumptions, including:

- opening time
- flow capacity
- closing time

C. Inlet Piping (see Note 2)

1. Piping stresses during valve discharge transient less than design stresses.
2. Piping support loads less than design loads.
3. Applied load on valve less than design load. (The design loads should consider the applied loads which resulted during testing.)

(1) It should be noted that when valve chatter occurred during non-loop seal tests, the valve was assisted open to terminate the event. Therefore, the degree of valve internals degradation during an actual in-plant event under similar conditions may be more severe than was observed in the testing.

(2) Load combinations and allowable piping stresses and support loads listed in Appendix E.

TABLE III-3 (Cont'd)

D. Discharge Piping (see Note 1)

1. Piping stresses during valve discharge transient less than design stresses.
2. Piping support loads less than design loads.
3. Maximum pressure less than maximum acceptable valve back pressure.
4. Applied load on valve less than design load.
(The design loads should consider the applied loads which resulted during testing.)

(1) Load combinations and allowable piping stresses and support loads listed in Appendix E.

TABLE III-4
RELIEF VALVE PERFORMANCE
SUMMARY SHEET

A. Parameters for Relief Valve Installation in Plant

The following parameters are to be tabulated for the plant installation. They are to be used to identify the tests with the representative valve.

1. Relief Valve
 - Manufacturer
 - Type
 - Size
2. Inlet Piping
 - Dry or loop-seal
3. Valve Operator
 - Air supply system details or electrical voltage/current
 - Other (size, force capacity)
4. Applicable Test Numbers

TABLE III-4 (Cont'd)

B. Valve Performance Summary

The following valve performance characteristics are to be determined from the data for the applicable tests.

Fluid Condition	Opening Time (sec)	Flow Capacity (lb/sec)	Closing Time (sec)
Saturated steam			
Water Seal			
Transition			
- Steam to water			
- Nitrogen to water			
Water (at high pressure set-point)			
- Maximum temperature			
- Minimum temperature			
Water (at low pressure set-point)			
- Maximum temperature			
- Minimum temperature			

TABLE III-5
LIST OF POTENTIAL PROBLEM AREAS AND
POSSIBLE ALTERNATIVES TO
ADDRESS UNDESIRABLE VALVE PERFORMANCE

<u>Potential Problem Areas</u>	<u>Possible Alternative</u>
<u>Safety Valves and Associated Piping</u>	
1. Valve blowdown required to provide stable valve performance for steam flow is not within FSAR/Tech Spec limits.	<p>Re-analyze selected NSSS system overpressure transients to show that increased valve blowdown is acceptable from the standpoint of plant operation considerations.</p> <p>(Note, since all plants are designed to accommodate losses of reactor coolant resulting from a range of possible size openings in the reactor coolant system, it is apparent that increased valve blowdown is not a safety concern.)</p> <p>Utilize alternative valve which provides stable performance with smaller blowdown.</p> <p>Relocate valve closer to pressurizer to allow stable performance to be obtained with reduced blowdown.</p>
2. Valve chatters with subcooled water flow conditions and blowdown cannot be adjusted to provide stable valve performance	<p>Show that subcooled water conditions can be handled by other than safety valve actuation, e.g., operator action or use of PORVs.</p> <p>Utilize alternative valve which performs in a stable manner with subcooled water, (e.g., Framatome/Crosby 6M6, or Target Rock 69C) or utilize an auxiliary lift device with the existing valve.</p>

TABLE III-5 (Cont'd)

<u>Potential Problem Area</u>	<u>Possible Alternative</u>
3. With cold loop seal arrangement, valve provides unacceptable performance, e.g.:	Provide a drain at low point in loop seal piping back to the pressurizer to prevent water accumulation ⁽¹⁾ .
- pressure oscillations (water hammer) in upstream piping	Provide heaters to increase temperature of loop seal water to near saturation (approximately 650°F). ⁽¹⁾
- delayed valve opening until loop seal clears	Utilize alternative valve which provides better performance with loop seal.
- high pressures and loads in discharge piping	

Relief Valves

With cold loop seal arrangement, valve closure following discharge is delayed

Provide a drain at low point in loop seal piping to prevent water accumulation⁽¹⁾.

Provide heaters to increase temperature of loop seal water.⁽¹⁾

Utilize alternative valve which is less sensitive to the thermal transient.

NOTE: (1) Before a decision to drain or heat the loop seals is made, careful consideration should be given to the potential for valve seat degradation and resulting steam/hydrogen leakage.

TABLE III-6

EPRI PWR SAFETY AND RELIEF VALVE TEST PROGRAM
 SAFETY VALVE TEST RESULTS SUMMARY (1)
 (CRITERIA: STABLE PERFORMANCE/NO CHATTER)

TESTED VALVES	INLET FLUID CONDITIONS					
	STEAM	LOOP SEAL	TRANSITION	650°F	WATER 550°F	400°F
• DRESSER 31739A SHORT INLET	YES	N/A ⁽²⁾	YES	YES	YES	YES ⁽⁵⁾
LONG INLET	YES	YES (4)	YES	YES	NO	-
• DRESSER 31709NA SHORT INLET	YES	N/A	YES	YES	YES	NO
LONG INLET ⁽³⁾	NO	-	-	-	-	-
• CROSBY 3K6 SHORT INLET	YES	N/A	YES	YES	NO	-
LONG INLET	YES	YES ⁽⁴⁾	NO	-	-	-
• CROSBY 6M6 LONG INLET	YES	YES ⁽⁴⁾	YES	YES	NO	-
• TARGET ROCK 69C LONG INLET	YES	YES	YES	YES (6)	YES (6)	YES (6)
• CROSBY 6N8 LONG INLET	YES	N/A	YES	YES	NO	-
• FRAMATOME/CROSBY 6M6 LONG INLET	YES	YES	YES	YES	YES	YES

NOTES:

- (1) The summary is for valve performance after reference test ring settings had been established and does not generally reflect expected performance with current in-plant ring settings.
- (2) Indicates the condition is not applicable to the valve/piping combination tested.
- (3) Plants which utilized this valve/piping combination have been modified and now have a short inlet.
- (4) Chatter observed on loop seal portion of test.
- (5) The valve had a limited lift and did not relieve the transient.
- (6) Observed inlet pressure fluctuations indicated possible valve flutter.

IV. SUGGESTED FORMAT FOR
JULY 1, 1982
PLANT-SPECIFIC SUBMITTAL

A suggested format for the July 1, 1982 plant-specific submittal to the NRC is provided in the following. It should be noted that the submittal outline is provided only as a general guideline for utility consideration and it is recognized that more or less information may need to be included in a particular plant-specific submittal.

I. DESCRIPTION OF SAFETY AND RELIEF VALVE INSTALLATION

This section should provide a summary description of the overall valve installation. In addition, this section should provide a list of key plant parameters as listed in Table IV-1, including:

- ° Safety valve parameters
- ° Relief valve parameters
- ° Inlet piping parameters
- ° Valve actuation transient parameters

II. RESULTS OF PLANT-SPECIFIC PERFORMANCE EVALUATIONS

A. Safety and Relief Valve Performance

This section should discuss the following:

1. Evaluation of pertinent test results and identification of conditions which could result in unacceptable valve performance.
2. Identification of modifications selected for implementation to provide acceptable performance.

B. Inlet and Discharge Piping Adequacy

This section should discuss:

1. Evaluation of stresses and support loads in inlet and discharge piping and identification of any overstressed piping or overloaded supports.
2. Identification of modifications required to provide acceptable stresses and loads in piping and supports.

III. CONCLUSIONS

IV. REFERENCES

This section should include a listing of all references utilized in the evaluations, including:

- A. Safety and Relief Valve Test Reports
- B. Valve Selection/Justification Report
- C. Plant and Test Condition Justification Reports
- D. Discharge Piping Load Model Report

V. APPENDICES

The following appendices should be included:

- A. Summary of report by valve manufacturers which justifies the acceptability of valves or the modification(s) selected for implementation.
- B. Summary of report by NSSS vendor which justifies the acceptability of the existing system or modification(s) selected for implementation.

- C. Summary results of calculations of inlet and discharge piping loads and stresses.
- D. Schedule for evaluation and implementation of modifications (if modifications are required).

TABLE IV-1
LIST OF KEY PLANT PARAMETERS

1. Safety Valve Information

- Valve Parameters

Number of valves

Manufacturer

Type

Size (inlet, outlet orifice)

Rated capacity (steam)

- Inlet Piping Parameters

Diameter

Length

Type (dry, loop seal/temperature)

- Actuation Transient Parameters

Fluid range (e.g., saturated steam, saturated water, subcooled water, etc.)

Maximum back pressure (steam condition)

2. Relief Valve Information

- Valve Parameters

Number of valves

Manufacturer

Type

Size (inlet, outlet, orifice)

Capacity (steam)

TABLE IV-1 (Cont'd)

- Inlet Piping Parameters

Type (dry, loop seal/temperature)

- Actuation Transient Parameters

Fluid range (e.g., saturated steam, saturated water,
subcooled water, etc.)

Maximum back pressure (steam condition)

V. REFERENCES

Following is a list of reports issued by EPRI to document the results of the safety and relief valve test program. Also noted are the draft and final publication dates of the report and the date when the report will be submitted to the NRC via the PWR utilities.

EPRI Report	Report Date		
	Draft	Final	Submitted to NRC
1. Safety and Relief Valve Test Report	3/1/82	4/1/82	4/1/82
2. Valve Selection/Justification Report	9/81	12/81	4/1/82
3. Test Condition Justification Report	3/5/82	4/1/82	4/1/82
4. B&W Plant Fluid Condition Justification Report	10/8/81	3/17/82	4/1/82
5. CE Plant Fluid Condition Justification Report	11/18/81	3/10/82	4/1/82
6. W Plant Fluid Condition Justification Report	10/8/81	1/29/82	4/1/82
7. Application of RELAP5/MOD1 for Calculation of Safety and Relief Valve Discharge Piping Hydrodynamic Loads (includes Discharge Piping Data)	3/5/82	4/1/82	4/1/82
8. Marshall Relief Valve Test Report	8/81	10/81	N/A
9. Wyle Phase II Relief Valve Test Report	9/81	12/81	N/A
10. Wyle Phase III Relief Valve Test Report	3/9/82	4/1/82	N/A
11. CE Safety Valve Test Report	6/1/82	7/1/82	N/A

N/A Not Applicable. These reports contain supplementary information.

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VI. APPENDICES

Revision 1

APPENDIX A
PROCEDURE FOR CALCULATION OF
VALVE BACK PRESSURE

A. Purpose

The purpose of this appendix is to provide a suggested procedure and guidelines for the calculation of safety and relief valve backpressure for the plant. This backpressure is to be compared with the test backpressure as discussed in Appendix D.

B. Discussion

Because of the sensitivity to back pressure exhibited by the safety valves in the EPRI test program, it is recommended that the plant back pressure be calculated on a realistic , rather than conservative, basis. Therefore, it is suggested that a hydraulic code such as RELAP or similar method be utilized. In this regard, EPRI has funded/developed a steady-flow hydraulic code specifically for determining valve backpressures. Further information regarding this code can be obtained from EPRI.

It is suggested that back pressure calculations be performed assuming simultaneous actuation of either all safety valves or all relief valves on steam. Also, use the maximum valve flow rates as determined by the valve manufacturer.

The computed steam backpressures are to be compared to those developed during EPRI steam tests to assess applicability. EPRI liquid testing was performed with the same discharge piping backpressure orifice as was utilized during a specified steam test. The backpressures developed during the liquid tests correspond to those expected in a plant having the same "steam" backpressure as was developed during the specified steam test. Therefore, if the steam backpressure developed exceeds the expected in-plant steam backpressure, the corresponding liquid backpressures developed will exceed those expected in the plant under similar conditions.

APPENDIX B
PROCEDURE FOR CALCULATION OF
INLET PIPING PRESSURE EFFECTS

A. Purpose

The purpose of this appendix is to provide a procedure for determining the inlet piping pressure drop associated with spring-loaded safety valve opening for the plant safety valve installation. This plant pressure drop is to be compared with the test pressure drop as discussed in Appendix D.

B. Discussion

The procedure described below is only applicable to high-quality steam-filled inlet piping installations which have a constant flow area. The method consists of calculating the inlet piping pressure drop due to flow pressure drop and acoustic wave propagation.

1. Inlet Piping Flow Pressure Drop (ΔP_F)

The flow pressure drop is given by,

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

where,

- k = expansion or contraction loss coefficient (dimensionless)
- f = friction factor (see Reference 1) (dimensionless)
- $\frac{L}{D}$ = piping equivalent length/diameter considering effects of fittings and friction (see Reference 1 for pertinent data) (dimensionless)
- \dot{M} = maximum valve flow rate for steam (as established by the safety valve manufacturer) (lb/sec)
- g_c = gravitational constant (32.2 lb-ft/lb-sec²)
- ρ = steam density at nominal valve set pressure (lb/ft³)
- A = inlet piping flow area (ft²)

2. Acoustic Wave Amplitude (ΔP_{AW})

The acoustic wave amplitude is calculated based on information in Reference 2. There are two situations to consider:

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

$$\Delta P_{AW} = \frac{a \dot{M}}{g_c A}$$

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

$$\Delta P_{AW} = \frac{2L \dot{M}}{g_c A T_{op}}$$

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.

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. For certain test valves, valve reopening and/or chatter was observed on valve closure. For similar valve/installations, the pressure rise associated with valve closure may have to be evaluated.

C. References

1. Flow of Fluids through Valves, Fittings and Pipe, Crane Co., Technical Paper No. 410, 1981.
2. Waterhammer Analysis, John Parmakian, Dover Publications, Inc., 1963.

D. Sample Problem

Following is a sample calculation of plant-specific pressure drop for an assumed safety valve/inlet piping configuration.

1. Flow Pressure Drop

An isometric of the assumed inlet piping configuration is provided in Figure B-1. The flow pressure drop is given by,

$$\Delta P_F = \frac{(k+1+fL) \dot{M}^2}{2g_c c A^2}$$

where,

$$k = 0.5^{(1)*} \text{ (sudden contraction at pressurizer nozzle)}$$

$$f = .016^{(1)}$$

$$\frac{L}{D} = \frac{33.6^{(1)}}{.432} + 6 \times 30^{(1)} + 2 \times 16^{(1)} = 289.8$$

$$\rho = 7.65 \text{ lb/ft}^3^{(2)} \text{ (saturated steam at 2500 psia)}$$

$$A = 0.147 \text{ ft}^2$$

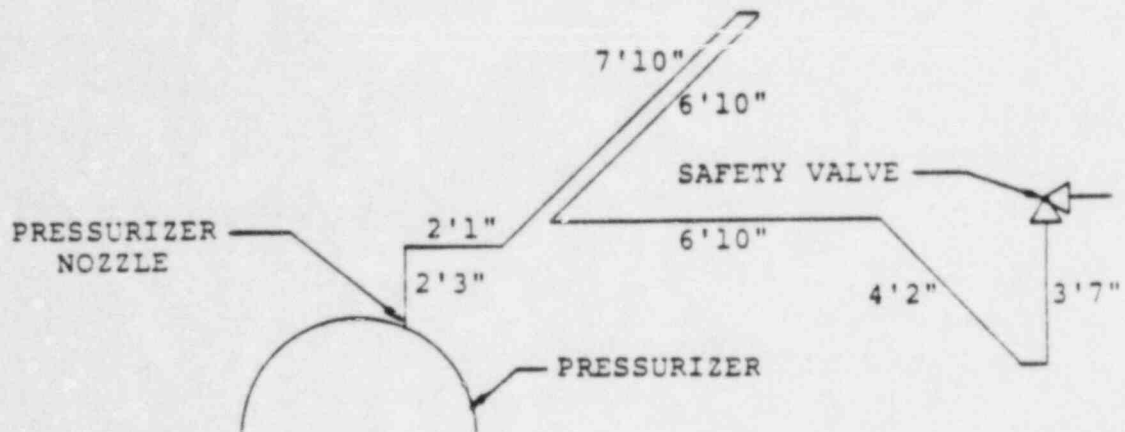
$$\dot{M} = \frac{345,000 \text{ lb/hr}}{3600 \text{ sec/hr}} = 95.8 \text{ lb/sec}$$

The flow pressure drop is,

$$\Delta P_F = \frac{(0.5 + 1 + .016 \times 289.8) \times 95.8^2}{64.4 \times 7.65 \times .147^2 \times 144}$$

$$\Delta P_F = 36 \text{ psi}$$

* Numbers in parentheses denote references listed at the end of this sample problem.



- TOTAL PIPE LENGTH = 33'7"
- PIPE DIAMETER = 6" SCH. 160 (5.189" INSIDE DIAM.)
- FITTINGS
 - ° 6, 90° ELBOWS
 - ° 2, 45° ELBOWS
- CROSBY 4M16 SAFETY VALVE
 - ° 345,000 lb/hr RATED CAPACITY
 - ° .010 SEC OPENING TIME

SAFETY VALVE INLET PIPING CONFIGURATION

FIGURE B-1

2. Acoustic Wave Amplitude

For the configuration in Figure B-1, the parameters are,

$$T_{op} = .010 \text{ sec}$$

$$\frac{2L}{a} = \frac{2 \times 33.6 \text{ ft}}{1300 \text{ ft/sec}^{(3)}} = .052 \text{ sec}$$

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

$$\Delta P_{AW} = \frac{a \dot{M}}{g_c A}$$

$$\Delta P_{AW} = \frac{1300 \times 95.8}{32.2 \times .147 \times 144}$$

$$\Delta P_{AW} = 183 \text{ psi}$$

3. Plant-Specific Pressure Drop

The plant-specific inlet piping pressure drop is given by,

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

$$\Delta P = 36 + 183 = 219 \text{ psi}$$

4. References

- (1) Flow of Fluids through Valves, Fittings and Pipe, Crane Co., Technical Paper No. 410, 1981.
- (2) ASME Steam Tables, 1967.
- (3) "A Pressure Pulse Model for Two-Phase Critical Flow and Sonic Velocity," ASME 68-WA/HT-8.

E. Test Valve/Inlet Pipe Configuration Inlet Piping
Pressure Drop

Following are Tables B.1 through B.6 entitled "Safety Valve Description and Inlet Piping Configuration".

These tables provide a description of the tested safety valves and the inlet piping configurations on which the valves were mounted. The information contained in these tables are the same as the information contained in Tables 3.1.1.a through 3.6.1.a of Reference 1 (see Section V) with the addition of the calculated transient pressure drop for each test inlet pipe configuration.

The transient pressure drops listed in each table are the calculated upstream pressure drops associated with valve opening for each test valve/inlet pipe configuration. Opening (Pop) times used to calculate the pressure drop are defined in footnote (1) of the tables. These opening times were established based on the opening times measured in the EPRI/PWR Safety and Relief Valve Test Program. The test data indicated that an opening time of 15ms for all of the Dresser safety valves tested and an opening time of 10ms for all of the Crosby safety valves tested were typical of the fastest opening times measured.

Since the test valves were selected to represent all participating PWR plant safety valve designs and the data indicated opening times which were consistent across the test valves, it is suggested that the opening times defined for each manufacturer's safety valve tested be used for the valve manufacturer's designs which were not tested.

EPRI/CE SAFETY VALVE TEST PROGRAM

TABLE B.1

SAFETY VALVE DESCRIPTION AND INLET PIPING CONFIGURATION DRESSER 31739A SAFETY VALVE

Valve Description

Manufacturer Dresser Industries
 Type Spring Loaded Safety Valve
 Model No. 31739 A
 Serial No. BH-04372
 Drawing No. 4CP-2432 Rev. 9
 Body Size (inlet/outlet) 2½ in./ 6 in.
 Bore Area 2.545 in.²
 Orifice Designation 3
 Design Set Point Pressure 2500 psig
 Design Blowdown 5 percent
 Rated Flow 297845 lb/hr. Rated Lift 0.45 in.
 Internals Type: Not applicable
 Ring Setting Reference Position:
 The ring setting positions refer to the number of
 notches relative to the following surfaces;
 Upper Ring - top holes in the guide
 Middle Ring- seat plane
 Lower Ring - seat plane

(1) This is the calculated transient upstream pressure drop associated with valve opening for this valve/inlet piping configuration. The pressure drop was calculated based on an opening time of 15 msec.

Inlet Piping Configuration "D"

	Length, in.	I.D., in.
Nozzle	17	6.813
Venturi	38	6.813
Pipe	11	6.813
Reducer	6	6.813/3.152
Loop Seal		
Straight	60	3.152
Bends	4-90°	6 in. radius
Reducer	4	3.152/2.125
Inlet Flange	6	2.125
Transient Pressure Drop (1)		<u>454</u> psi

Inlet Piping Configuration "C"

	Length, in.	I.D., in.
Nozzle	17	6.813
Venturi	38	6.813
Pipe	11	6.813
Reducer	10	6.813/2.125
Pipe		Not applicable
Inlet Flange	6	2.125
Transient Pressure Drop (1)		<u>54</u> psi

EPRI/CE SAFETY VALVE TEST PROGRAM

TABLE B.2

SAFETY VALVE DESCRIPTION AND INLET PIPING CONFIGURATION

DRESSER 31709NA

Valve Description

Manufacturer Dresser Industries
 Type Spring Loaded Safety Valve
 Model No. 31709A
 Serial No. BQ07681
 Drawing No. 4CP-2332 Rev 11

Body Size (inlet/outlet) 6 in./ 8 in.
 Bore Area 4.34 in.²
 Orifice Designation N

Design Set Point Pressure 2500 psig

Design Blowdown 5 percent

Rated Flow 507918 lb/hr. Rated Lift 0.588 in.

Internals Type: not applicable

Ring Setting Reference Position:

The ring setting positions refer to the number of notches relative to the following surfaces;

Upper Ring - top holes in the guide
 Middle Ring- seat plane
 Lower Ring - seat plane

- (1) This is the calculated transient upstream pressure drop associated with valve opening for this valve/inlet piping configuration. The pressure drop was calculated based on an opening time of 15msec.

Inlet Piping Configuration

Length, in.

"A"

I.D., in.

Nozzle	17	6.813
Venturi	38	6.813
Pipe	6	6.813
Reducer	6	6.813/4.897
Loop Seal		
Straight	48	4.897
Bends	2 Bends 180°, 9" radius	
Reducer	not applicable	
Inlet Flange	11	4.897

Transient Pressure Drop (1) NOT AVAILABLE

Inlet Piping Configuration

Length, in.

"B"

I.D., in.

Nozzle	17	6.813
Venturi	38	6.813
Pipe	6	6.813
Reducer	6	6.813/4.897
Pipe	not applicable	
Inlet Flange	11	4.897

Transient Pressure Drop (1) 88 psi

EPRI/CE SAFETY VALVE TEST PROGRAM

TABLE B.3

SAFETY VALVE DESCRIPTION AND INLET PIPING CONFIGURATION

FOR THE CROSBY HB-BP-86 3K6 (STEAM INTERNALS)

Valve Description

Manufacturer Crosby Valve and Gage
Type Spring Loaded Safety
Model No. HB-BP-86 3K6
Serial No. None
Drawing No. SK-3658-V

Body Size (inlet/outlet) 3 in./6 in.
Bore Area 1.841 in.²
Orifice Designation K

Design Set Point Pressure 2485 psig

Design Blowdown 5 percent

Rated Flow 212,182 lb/hr. Rated Lift 0.382 in.

Internals Type: Steam

Ring Setting Reference Position:

The ring setting position refers to the number of notches relative to the bottom of the ring disc.

- (1) This is the calculated transient upstream pressure drop associated with valve opening for this valve/inlet piping configuration. The pressure drop was calculated based on an opening time of 10msec.

Inlet Piping Configuration "F"
Length, in.

I.D., in.

Nozzle	17	6.813
Venturi	38	6.813
Pipe	6	6.813
Reducer	6	6.813
Loop Seal		
Straight	54	3.152
Bends	4-90°	6 inches radius
Reducer	4	3.152/2.624
Inlet Flange	7	2.624

Transient Pressure Drop (1) 321 psi

Inlet Piping Configuration "E"
Length, in.

I.D., in.

Nozzle	17	6.813
Venturi	38	6.813
Pipe	6	6.813
Reducer	10	6.813/2.624
Pipe	4	2.624
Inlet Flange	7	2.624

Transient Pressure Drop (1) 56 psi

EPRI/CE SAFETY VALVE TEST PROGRAM

TABLE B.4

SAFETY VALVE DESCRIPTION AND INLET PIPING CONFIGURATION

FOR THE CROSBY HB-BP-86 3K6 (LOOP SEAL INTERNALS)

Valve Description

Manufacturer Crosby Valve and Gage
Type Spring Loaded Safety
Model No. HB-BP-86 3K6
Serial No. None
Drawing No. SK-3658-V

Body Size (inlet/outlet) 3 in./ 6 in.
Bore Area 1.841 in.²
Orifice Designation K

Design Set Point Pressure 2485 psig

Design Blowdown 5 percent

Rated Flow 212,182 lb/hr. Rated Lift 0.382 in.

Internals Type: Loop Seal

Ring Setting Reference Position:
The reported measurements are relative to
the bottom of the disc ring.

- (1) This is the calculated transient upstream pressure drop associated with valve opening for this valve/inlet piping configuration. The pressure drop was calculated based on an opening time of 10msec.

Inlet Piping Configuration "F"
Length, in.

I.D., in.

Nozzle	17	6.813
Venturi	38	6.813
Pipe	6	6.813
Reducer	6	6.813/3.152
Loop Seal Straight Bends	54 4-90°	3.152 6 inches radius
Reducer	4	3.152/2.624
Inlet Flange	7	2.624

Transient Pressure Drop (1) 321 psi

Inlet Piping Configuration "E"
Length, in.

I.D., in.

Nozzle	17	6.813
Venturi	38	6.813
Pipe	6	6.813
Reducer	10	6.813/2.624
Pipe	4	2.624
Inlet Flange	7	2.624

Transient Pressure Drop (1) 56 psi

EPRI/CE SAFETY VALVE TEST PROGRAM

TABLE B.5

SAFETY VALVE DESCRIPTION AND INLET PIPING CONFIGURATION
FOR THE CROSBY HB-BP-86 6M6 (LOOP SEAL INTERNALS)

<u>Valve Description</u>		<u>Inlet Piping Configuration</u>		"G" Length, in.	I.D., in.
Manufacturer	Crosby Valve and Cage Company	Nozzle	17		6.813
Type	Spring Loaded Safety Valve				
Model No.	HB-BP-86 6M6	Venturi	38		6.813
Serial No.	N56964-00-0086				
Drawing No.	Crosby DS-C-56964 Rev. C	Pipe	13		6.813
Body Size (inlet/outlet)	6 in./ 6 in.	Reducer	6		6.813/4.897
Bore Area	3.644 in. ²				
Orifice Designation	M	Loop Seal			
		Straight	48		4.897
Design Set Point Pressure	2485 psig	Bends	2-180°		9 in. radius
Design Blowdown	5 percent				
Rated Flow	420,006 lb/hr.				
Rated Lift	0.538 in.				
Internals Type	Loop Seal				
		Reducer			Not Applicable
Ring Setting Reference Position					
The ring setting position refers to the number of notches relative to the bottom of the disc ring.		Inlet Flange	10		4.897
		Transient Pressure Drop (1)	251		nsi

(1) This is the calculated transient upstream pressure drop associated with valve opening for this valve/inlet piping configuration. The pressure drop was calculated based on an opening time of 10 msec.

EPRI/CE SAFETY VALVE TEST PROGRAM

TABLE B.6

SAFETY VALVE DESCRIPTION AND INLET PIPING CONFIGURATION FOR THE CROSBY HB-BP-86 6NB (STEAM INTERNALS)

Valve Description		Inlet Piping Configuration "H"		
		Length, in.	I.D., in.	
Manufacturer	Crosby Valve and Gage Company	Nozzle	17	6.813
Type	Spring Loaded Safety Valve	Venturi	Not Applicable	
Model No.	HB-BP-86 6NB	Pipe	9	6.813
Serial No.	N61894-00-0006	Reducer	6	6.813/5.189
Drawing No.	Crosby DSC- 61894 Rev. D	Pipe	76	5.189
Body Size (inlet/outlet)	6 in./ 8 in.	Inlet Flange	7	5.189
Bore Area	4.381 in. ²			
Orifice Designation	N			
Design Set Point Pressure	2485 psig			
Design Blowdown	5 percent			
Rated Flow	504,952 lb/hr.			
Rated Lift	0.591 in.			
Internals Type:	Steam	Transient Pressure Drop (1)	270 psi	
Ring Setting Reference Position:				
The ring setting position refers to the number of notches relative to the bottom of the disc ring.				

- (1) This is the calculated transient upstream pressure drop associated with valve opening for this valve/inlet piping configuration. The pressure drop was calculated based on an opening time of 10 msec.

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APPENDIX C

PROCEDURE FOR VERIFICATION OF
ALTERNATIVE METHODS TO BE USED IN
EVALUATION OF PIPING/SUPPORT ADEQUACY

As discussed in Section II of this guide, the utility may elect to use an alternative method to perform the evaluation of piping/support adequacy. In this event, it is recommended that the adequacy of the alternative method be verified by comparison with the EPRI test data provided in Reference 7 (see Section V). This can be accomplished by one of the following approaches:

- ° By direct comparison between the analytical method predictions and the data measured in the CE Facility tests.
- ° By comparison between the hydraulic forcing function determined by the alternative method with the forcing function determined by the EPRI-provided code (RELAP5).

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APPENDIX D

PROCEDURE FOR ASSESSMENT OF
APPLICABILITY OF SPECIFIC EPRI
SAFETY VALVE TESTS

A. Purpose

The purpose of this appendix is to provide a procedure for use by the valve manufacturers (or utilities) in assessing the applicability of specific EPRI tests to plant safety valve installations. This procedure is based on directly using test results from the EPRI program in the plant-specific evaluation. Thus, the key is to establish that one or more of the representative valve/piping configurations tested by EPRI closely matches the plant installation. It is expected this approach will be useful for virtually all the plant evaluations.

B. Discussion

The results of the EPRI safety valve tests indicate that there are a number of key parameters which effectively control the response of the safety valves.

These parameters are:

- Valve ring settings (for spring-loaded safety valves only)
- Discharge piping backpressure
- Inlet piping pressure effects associated with valve opening (for spring-loaded safety valves only)

- Inlet fluid conditions (e.g., saturated steam, saturated water, subcooled water).

A suggested procedure for assessing the applicability of specific EPRI tests to various plant installations is provided in Table D-1. This procedure involves following four steps to determine the applicability of a particular test or test series. Note that if tests are not found to be directly applicable to the plant valve evaluation, the EPRI test data base combined with other existing test data and/or analysis would have to be used to establish the expected valve performance in the plant.

C. Sample Evaluation

Table D-2 provides the results of a sample test applicability assessment for a Dresser safety valve, Model 31759A using test data for Dresser safety valve Models 31739A and 31709NA. This case is the more complex of the two options identified in Table D-1: a valve not directly tested, but one for which the valve manufacturer can identify ring settings which provide similar performance. Further, the evaluation requires comparison to two different representative valve/piping configuration tests to assess the expected performance of the valve.

The results of the sample evaluation are discussed in the following:

- o Test 1 -- The test is directly applicable because the valve ring settings, plant backpressure, inlet piping pressure and fluid condition requirements specified in Table D-1 are satisfied.
- o Test 2 -- The test is directly applicable because the valve ring settings, plant backpressure, inlet piping pressure and fluid condition requirements specified in Table D-1 are satisfied.
- o Test 3 -- This test is not directly applicable because the plant backpressure is greater than the test backpressure.
- o Test 4 -- This test is not directly applicable because the plant inlet piping pressure drop is greater than the test inlet piping pressure drop.

- ° Test 5 -- This test is not directly applicable because the plant valve ring settings do not correspond to those specified by the valve manufacturer to provide similar performance to the test valve.

- ° Test 6 -- This test is directly applicable because the valve ring settings, plant backpressure, inlet piping pressure and fluid condition requirements specified in Table D-1 are satisfied.

In this sample assessment, the Dresser Model 31759A safety valve is determined to provide acceptable performance for steam inlet conditions (at a plant backpressure of 400 psia and an inlet piping pressure drop of 150 psi), and unacceptable performance for 550°F water inlet conditions. Based on the six tests listed in Table D-2, no direct indication can be obtained of the safety valve performance for the 650°F and 450°F water inlet conditions. However, from a review of the safety valve test results summarized in Table III-6 of this guide, it is apparent that valve performance would be acceptable for 650°F water and unacceptable for 450°F water.

TABLE D-1

PROCEDURE FOR ASSESSMENT OF
APPLICABILITY OF SPECIFIC EPRI TESTS

- STEP A -- VALVE RING SETTINGS

• For Valves Tested in the EPRI Program:

1. Are the ring settings for the plant valve the same as for the tested valve?
2. If the answer to the above question is yes, proceed to Step B.
3. If the answer to the above question is no, the test is not directly applicable to the plant evaluation.

• For Valves not Tested in the EPRI Program:

1. Is the plant valve represented by a test valve per Reference 2 (see Section V)?
2. Do the ring settings for the plant valve correspond to those specified by the valve manufacturer to obtain similar performance as observed for the test valve?
3. If the answers to Questions 1 and 2 are both yes, proceed to Step B.
4. If the answer to either Question 1 or 2 is no, the test is not directly applicable to the plant evaluation.

TABLE D-1 Cont'd

- STEP B -- DISCHARGE PIPING BACKPRESSURE
(See Appendix A for the procedure for
calculating plant backpressure)

1. Is the plant backpressure less than the backpressure in the test? (This comparison should be made for steam discharge condition as discussed in Appendix A.)
2. If the answer to the above question is yes, proceed to Step C.
3. If the answer to the above question is no, the test is not directly applicable to the plant evaluation. (However, if unacceptable valve performance was observed in the test, it is highly probable that unacceptable valve performance would also result at the plant backpressure condition.)

TABLE D-1 (Cont'd)

- STEP C -- INLET PIPING PRESSURE EFFECTS*
(See Appendix B for the procedure of
calculating plant inlet piping pressure effects)

1. Is the plant inlet piping pressure drop due to valve opening less than the corresponding value for the test? (This comparison should be made for the steam discharge condition as discussed in Appendix B.)
2. If the answer to the above question is yes, proceed to Step D.
3. If the answer to the above question is no, the test is not directly applicable to the plant evaluation. (However, if unacceptable valve performance was observed in the test, it is also highly probable that unacceptable valve performance would also result at the plant inlet piping pressure drop condition.)

* The procedure outlined in this step should only be used for those plant installations which have the same or smaller valve nozzle and the same inlet nominal piping diameter as those tested. For other cases, a different evaluation method may be required. In this regard, EPRI has funded/developed an analytical method that can be used for these evaluations. Further information regarding this method can be obtained from EPRI.

TABLE D-1 (Cont'd)

- STEP D -- INLET FLUID CONDITION

1. Is the inlet fluid condition for the plant (see list in Table II-1 of this guide) the same as the inlet fluid condition for the test?
2. If the answer to the above question is yes, the applicability assessment is complete and the test is determined to be applicable to the plant evaluation.
3. If the answer to the above question is no, the test is not directly applicable to the plant evaluation.

TABLE D-2

SAMPLE TEST APPLICABILITY ASSESSMENTS ***

	<u>PLANT A</u>	<u>TEST 1</u>	<u>TEST 2</u>	<u>TEST 3</u>	<u>TEST 4</u>	<u>TEST 5</u>	<u>TEST 6</u>
VALVE MAKE/MODEL	DRESSER 31759A	DR31739A	DR31709NA	DR31739A	DR31739A	DR31739A	DR31739A
RING SETTINGS	+X,-Y,+Z*	+48,-40, +11	+50,-27, +10	+48,-40, +11	+48,-40, +11	+100,-30, -10	+48,-40, +11
BACKPRESSURE (STEAM) (PSIG)	400	650	600	300	650	650	300**
INLET PIPING PRESSURE DROP (PSI)	150	250	300	250	40	250	250
INLET FLUID COND.	STEAM, WATER (650,550, 400°F)	STEAM	STEAM	STEAM	STEAM	STEAM	WATER (550°F)
OBSERVED PERFORMANCE	N/A	GOOD	GOOD	GOOD	GOOD	BAD	BAD
TEST APPLICABLE?	N/A	YES	YES	NO	NO	NO	YES

* RING SETTINGS RECOMMENDED BY VALVE VENDOR BASED ON REVIEW OF EPRI TEST DATA AND INTENDED TO PROVIDE SIMILAR PERFORMANCE TO THE 31739A AND THE 31709NA TEST VALVES.

** SAME DISCHARGE PIPE ORIFICE USED WHICH RESULTED IN A 650 PSIG BP ON STEAM
 *** VALUES SHOWN FOR ILLUSTRATION ONLY, ACTUAL VALUES SHOULD BE OBTAINED FROM REFERENCE 1 (SEE SECTION V).
 THE INLET PIPING PRESSURE DROP INFORMATION IS CONTAINED IN APPENDIX B (PARAGRAPH E).

Revision 1

Revision 1

APPENDIX E
LOAD COMBINATIONS AND
ACCEPTANCE CRITERIA FOR THE
SAFTTY AND RELIEF VALVE PIPING EVALUATION

A. Purpose

The purpose of this appendix is to provide suggested load combinations and acceptance criteria for the pressurizer safety and relief valve piping system.

During the course of the EPRI valve program, an ad hoc group was established to help insure analysis consistency regarding discharge piping. The recommended load combinations and acceptance criteria provided in the following section were developed by this group and are being supplied to you for your consideration.

B. Discussion

The recommended load combinations and acceptance criteria for the pressurizer safety and relief valve piping system and supports are shown in Tables 1, 2A and 2B.

Tables 2A and 2B are for the discharge, or downstream, piping and supports. Table 2A applies to the portion for which seismic requirements apply. There are two possible approaches to this requirement. The entire downstream portion may be seismically designed, in which case, only Table 2A need be used. If only a portion of the downstream system is seismically designed (e.g., to the first downstream anchor, or enough supports and piping to effectively isolate the seismic and non-seismic portions), then Table 2A would apply for that portion, while Table 2B would apply to the rest of the downstream system.

For the seismically designed downstream piping and supports, less restrictive allowables are suggested. Since satisfaction of allowable valve loading is part of the acceptance criteria, this would appear to be acceptable.

For the non-seismically designed portion of the downstream piping, it is recommended that the pipe support system be seismically designed to assure overall structural integrity of the system. It is suggested that Service Level D limits be applied for all pipe support load combinations containing OBE or SSE.

TABLE 1

LOAD COMBINATIONS AND ACCEPTANCE CRITERIA FOR PRESSURIZER SAFETY
AND RELIEF VALVE PIPING AND SUPPORTS - CLASS 1 PORTION

<u>Combination</u>	<u>Plant/System Operating Condition</u>	<u>Load Combination</u>	<u>Service Stress Limit</u>
1	Normal	N	A
2	Upset	N + OBE + SOT _U	B
3	Emergency	N + SOT _E	C
4	Faulted	N + MS/FWPB or DBPB + SSE + SOT _F	D
5	Faulted	N + LOCA + SSE + SOT _F	D

NOTES:

- 1.) Plants without an FSAR may use the proposed criteria contained in Tables 1-3. Plants with an FSAR may use their original design basis in conjunction with the appropriate system operating transient definitions in Table 3; or they may use the proposed criteria contained in Tables 1-3.
- 2.) See Table 3 for SOT definitions and other load abbreviations.
- 3.) The bounding number of valves (and discharge sequence if setpoints are significantly different) for the applicable system operating transient defined in Table 3 should be used.
- 4.) Verification of functional capability is not required, but allowable loads and accelerations for the safety-relief valves must be met.
- 5.) Use SRSS for combining dynamic load responses.

TABLE 2A

LOAD COMBINATIONS AND ACCEPTANCE CRITERIA FOR PRESSURIZER SAFETY
AND RELIEF VALVE PIPING AND SUPPORTS - SEISMICALLY DESIGNED DOWNSTREAM PORTION

<u>Combination</u>	<u>Plant/System Operating Condition</u>	<u>Load Combination</u>	<u>Service Stress Limit</u>
1	Normal	N	A
2	Upset	$N + SOT_U$	B
3	Upset	$N + OBE + SOT_U$	C
4	Emergency	$N + SOT_E$	C
5	Faulted	$N + MS/FWPE \text{ or } DBPB$ $+ SSE + SOT_F$	D
6	Faulted	$N + LOCA + SSE + SOT_F$	D

- NOTES: 1.) Plants without an FSAR may use the proposed criteria contained in Tables 1-3. Plants with an FSAR may use their original design basis in conjunction with the appropriate system operating transient definitions in Table 3; or they may use the proposed criteria contained in Tables 1-3.
- 2.) This table is applicable to the seismically designed portion of downstream non-Category I piping (and supports) necessary to isolate the Category I portion from the non-seismically designed piping response, and to assure acceptable valve loading on the discharge nozzle.
- 3.) See Table 3 for SOT definitions and other load abbreviations.
- 4.) The bounding number of valves (and discharge sequence if setpoints are significantly different) for the applicable system operating transient defined in Table 3 should be used.
- 5.) Verification of functional capability is not required, but allowable loads and accelerations for the safety/relief valves must be met.
- 6.) Use SRSS for combining dynamic load responses.

TABLE 2B

Revision 1

LOAD COMBINATIONS AND ACCEPTANCE CRITERIA FOR PRESSURIZER
SAFETY AND RELIEF VALVE PIPING AND SUPPORTS -
NON-SEISMICALLY DESIGNED DOWNSTREAM PORTION

PIPING

<u>Combination</u>	<u>Plant/System Operating Condition</u>	<u>Load Combination</u>	<u>Service Limit</u>
1	Normal	N	A
2	Upset	N + SOT _U	B
3	Emergency	N + SOT _E	C
4	Faulted	N + SOT _F	D

SUPPORTS

<u>Combination</u>	<u>Plant/System Operating Condition</u>	<u>Load Combination</u>	<u>Service Limit</u>
1	Normal	N	A
2	Upset	N + SOT _U	B
3	Upset	N + OBE + SOT _U	D
4	Emergency	N + SOT _E	C
5	Faulted	N + MS/FWPB or DBPB + SSE + SOT _F	D
6	Faulted	N + LOCA + SSE + SOT _F	D

- NOTES: 1.) Plants without an FSAR may use the proposed criteria contained in Tables 1-3. Plants with an FSAR may use their original design basis in conjunction with the appropriate system operating transient definitions in Table 3; or they may use the proposed criteria contained in Tables 1-3.
- 2.) Pipe supports for the non-seismically designed down-stream piping should be designed for seismic load combinations to assure overall structural integrity of the system.
- 3.) The bounding number of valves (and discharge sequence if setpoints are significantly different) for the applicable system operating transient defined in Table 3 should be used.
- 4.) Verification of functional capability is not required, but allowable loads and accelerations for the safety/relief valves must be met.
- 5.) Use SRSS for combining dynamic load responses.

TABLE 3DEFINITIONS OF LOAD ABBREVIATIONS

N	= Sustained Loads During Normal Plant Operation
SOT	= System Operating Transient
SOT _U	= Relief Valve Discharge Transient ⁽¹⁾
SOT _E	= Safety Valve Discharge Transient ⁽¹⁾
SOT _F	= Max (SOT _U ; SOT _E); or Transition Flow
OBE	= Operating Basis Earthquake
SSE	= Safe Shutdown Earthquake
MS/FWPB	= Main Steam or Feedwater Pipe Break
DBPB	= Design Basis Pipe Break
LOCA	= Loss of Coolant Accident

- (1) May also include transition flow, if determined that required operating procedures could lead to this condition.
- (2) Although certain transients (for example loss of load) which are classified as a service level B conditions may actuate the safety valves, the extremely low probability of actual safety valve actuation may be used to justify this as a service level C condition with the limitation that the plant will be shut down for examination after an appropriate number of actuations (to be determined on a plant specific basis).

NOTE: Plants without an FSAR may use the proposed criteria contained in Tables 1-3. Plants with an FSAR may use their original design basis in conjunction with the appropriate system operating transient definitions in Table 3; or they may use the proposed criteria contained in Tables 1-3.