Revision 2

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

INTERIM REPORT, JULY 1982
(RESEARCH PROJECT V102)

Prepared by:

MPR Associates, Inc.
1140 Connecticut Avenue, N.W.
Washington, D.C. 20036

Prepared for:

Participating PWR Utilities
and
Electric Power Research Institute
3412 Hillview Avenue
Palo Alto, California 94304

EPRI Project Managers:
T. E. Auble
J. F. Hosler

PWR Safety and Relief Valve Test Program
Nuclear Power Division

## 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.

# TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

# 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 functionability 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.

o 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.

F. Justification of Relief Valve Test Conditions for Plant Cold Overpressurization Events

This appendix provides a suggested procedure to be used by the utilities to justify that the conditions under which the relief valve was tested are representative of the conditions expected for plant cold overpressurization events.

# 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.

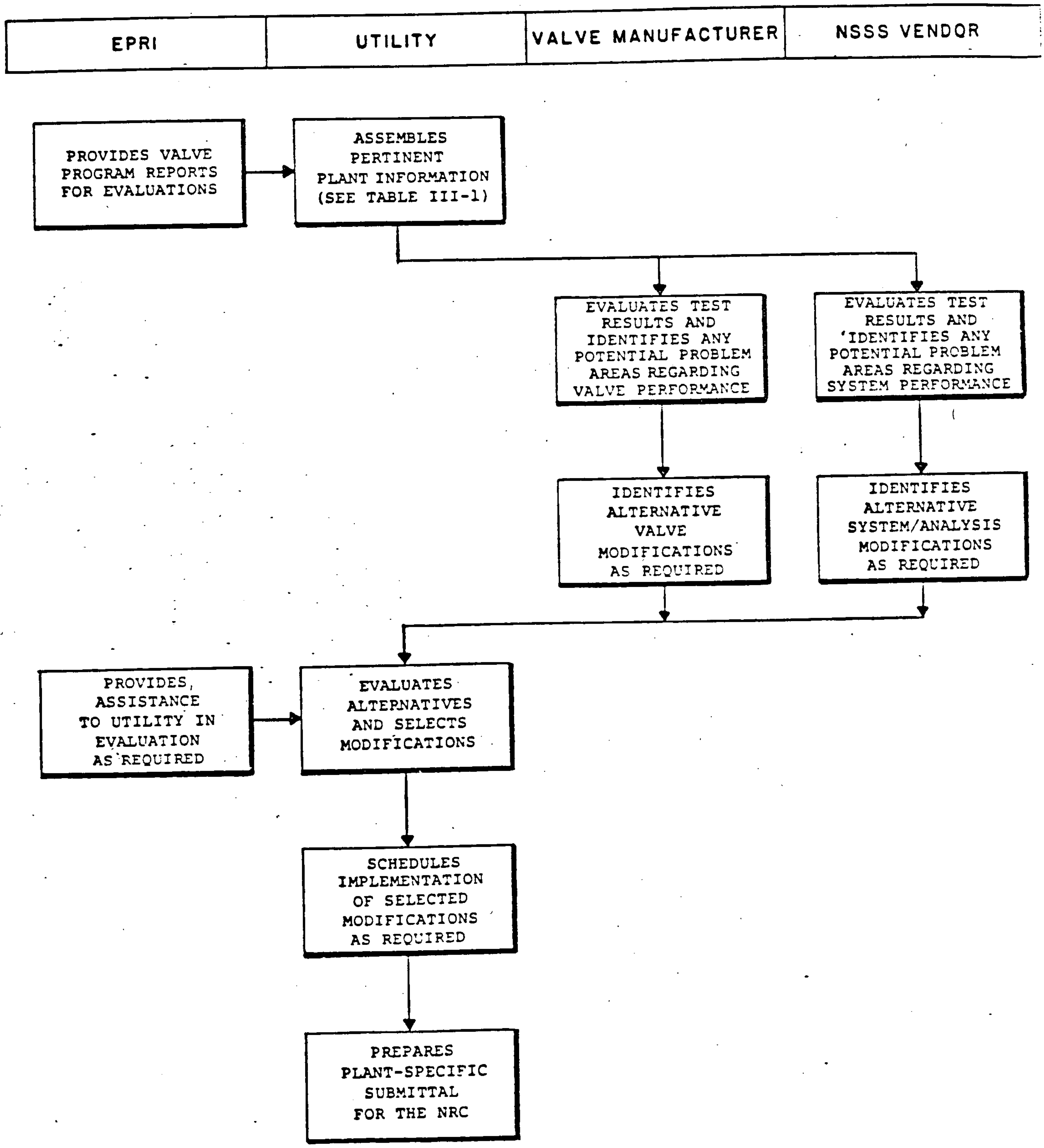
B. Workscopes for the Evaluations

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

## 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

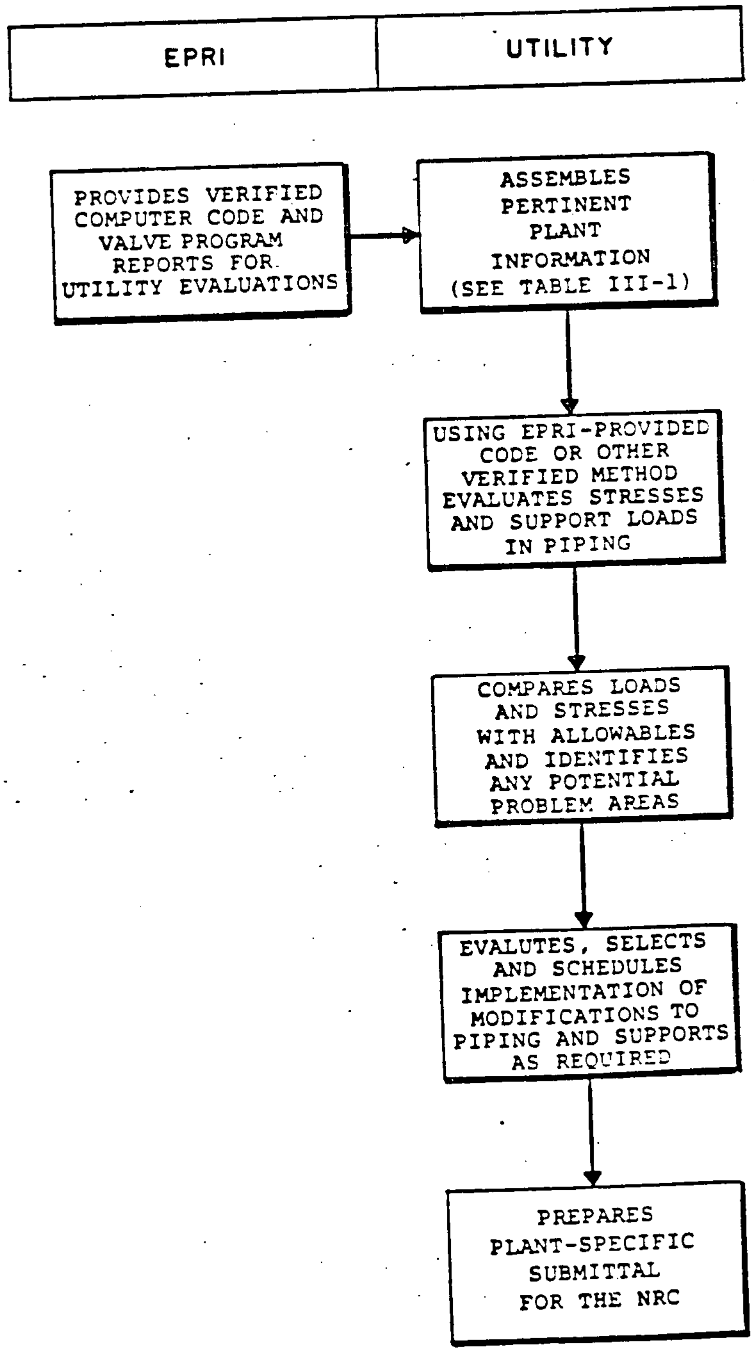


TABLE II-3

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(1) (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.

---

(1) Justification of conditions resulting from cold overpressurization events is not presented in the test conditions justification report for certain PWR plant units. For these units, the justification should be provided as part of the utilities' plant-specific evaluations. A suggested approach to be followed in providing this justification is contained in Appendix F to this report.

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).

   No Full Flow Test were done on Short pipe (Loop seals) to establish performance and ring settings

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 ASSEMBLIED 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 Settings | |
|---|---|---|
| Ring | 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

| Potential Problem Areas | Possible Alternative |
|---|---|
| Safety Valves and Associated Piping | |
| 1. Valve blowdown required to provide stable valve performance for steam flow is not within FSAR/Tech Spec limits. | Re-analyze selected NSSS system overpressure transients to show that increased valve blowdown is acceptable from the standpoint of plant operation considerations.<br><br>(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.)<br><br>Utilize alternative valve which provides stable performance with smaller blowdown.<br><br>Relocate valve closer to pressurizer to allow stable performance to be obtained with reduced blowdown. |
| 2. Valve chatters with subcooled water flow conditions and blowdown cannot be adjusted to provide stable valve performance | Show that subcooled water conditions can be handled by other than safety valve actuation, e.g., operator action or use of PORVs.<br><br>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. |

TABLE III-5 (Cont'd)

| Potential Problem Area | Possible Alternative |
| --- | --- |
| 3. With cold loop seal arrangement, valve provides unacceptable performance, e.g.:<br>- pressure oscillations (water hammer) in upstream piping<br>- delayed valve opening until loop seal clears<br>- high pressures and loads in discharge piping | Provide a drain at low point in loop seal piping back to the pressurizer to prevent water accumulation[(1)].<br><br>Provide heaters to increase temperature of loop seal water to near saturation (approximately 650°F).[(1)]<br><br>Utilize alternative valve which provides better performance with loop seal. |
| **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)].<br><br>Provide heaters to increase temperature of loop seal water.[(1)]<br><br>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 | WATER 650°F | WATER 550°F | WATER 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.

# VI. APPENDICES

# APPENDIX A

## PROCEDURE FOR CALCULATION OF VALVE BACK PRESSURE

A. <u>Purpose</u>

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. <u>Discussion</u>

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 <u>or</u> all relief valves on steam or with a loop seal if one is present. Consideration should be given to the effects of accelerating the loop seal in the discharge piping on the transient back pressure. This can most easily be done by using RELAP5/MOD1 with the appropriate portion of the loop seal initially placed downstream of the valve. 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 or the pressure rise associated with valve closing for the plant safety valve installation. This plant pressure difference is to be compared with the test pressure difference as discussed in Appendix D. As discussed in Appendix D, if the plant pressure difference is less than the test pressure difference, the in-plant valve would be expected to have performance at least as stable as the tested valve.

B. Discussion

The procedure described below is only applicable to inlet piping installations which have a constant flow area*. The method consists of calculating the transient inlet piping pressure difference due to flow effects and acoustic wave propagation and the steady-state flow pressure difference for both valve opening and closing. The larger of these pressure differences (transient versus steady-state) is to be used in the plant versus test comparison discussed in Appendix D. Note that the inlet piping pressure differences must be computed both for valve opening and for valve closing**.

* The procedure can also be used for in-plant piping with a reducer at the pressurizer nozzle exit and/or just upstream of the valve inlet.

** The equations in this appendix should only be used for the purpose of determining the inlet piping pressure differences for use in the plant versus test comparison discussed in Appendix D. They should not be used for the purpose of determining absolute values of the pressure differences (e.g., for the purpose of determining the required valve blowdown setting for the plant installation).

1. Transient Flow Pressure Difference ($\Delta P_F$) Calculation

The flow pressure difference due to pipe friction and fittings is given by:

- If $T \leq 2L/a$,

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

- If $T > 2L/a$,

$$\Delta P_F = \frac{(K + \frac{fL}{D})(C\dot{M})^2 (\frac{2L}{aT})^2}{2g_c \rho A^2}$$

where,

$K$ = summation of expansion and contraction loss coefficients corrected if required to correspond to the inlet piping flow area. (NOTE: The contraction from the pressurizer to the inlet pipe can be assumed to be smooth and therefore the loss coefficient can be assumed to be zero) (dimensionless)

$f$ = friction factor (see Reference 1) (dimensionless)

$\frac{L}{D}$ = piping equivalent length/diameter considering effects of elbows and friction (see Reference 1 for pertinent data) (dimensionless)

$\dot{M}$ = rated valve flow rate for steam as specified in Table B-1 (lb/sec)

$g_c$ = gravitational constant (32.2 lb-ft/lb-sec$^2$)

$\rho$ = steam density at nominal valve set pressure (lb/ft$^3$)

$A$ = inlet piping flow area (ft$^2$)

$a$ = steam sonic velocity (ft/sec) - use 1100 ft/sec for all calculations

L = inlet piping length (from the pressurizer inside diameter to the interface between the inlet pipe flange and the valve inlet flange) (ft)

T = valve opening or closing time for steam inlet conditions as specified in Table B-2 (sec)

C = flow rate constant for valve opening or closing as specified in Table B-2

2. Transient Acoustic Wave Amplitude ($\Delta P_{AW}$) Calculation

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

- If $T \leq 2L/a$,

$$\Delta P_{AW} = \frac{a(C\dot{M})}{g_c A} + \frac{(C\dot{M})^2}{2 g_c \rho A^2}$$

- If $T > 2L/a$,

$$\Delta P_{AW} = \frac{2L\ (C\dot{M})}{g_c AT} + \frac{(C\dot{M})^2 \left(\frac{2L}{at}\right)^2}{2\ g_c \rho A^2}$$

All parameters are defined in Section B.1 above.

3. Plant-Specific Transient Pressure Difference Calculation

The plant-specific transient pressure difference associated with valve opening or closing is equal to the sum of the flow pressure difference ($\Delta P_F$) and the acoustic wave amplitude ($\Delta P_{AW}$) as determined above.

4. Plant-Specific Steady-State Flow Pressure Difference Calculation

The steady-state flow pressure difference associated with valve opening or closing is given by:

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

All parameters are defined in Section B.1 above. Note that the values of the flow rate constant, C, are different for valve opening and closing and are provided in Table B-2.

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 Problems

1. Problem #1

Following is a sample calculation of the plant-specific pressure difference for the assumed safety valve/inlet piping configuration illustrated in Figure B-1.

a. Valve Opening

From Table B-2, the opening time is,

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

Also,

$$\frac{2L}{a} = \frac{2 \times 33.6 \text{ ft}}{1100 \text{ ft/sec}} = .061 \text{ sec}$$

Therefore,

$$T_{op} < \frac{2L}{a}$$

(1) Transient Flow Pressure Difference

Since $T_{op} < \frac{2L}{a}$, the flow pressure difference is,

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

where,

$$\dot{M} = \frac{376{,}000 \text{ lb/hr}}{3600 \text{ sec/hr}} = 104.4 \text{ lb/sec}$$

C = 1.11 (from Table B-2)

$$K = (K_{expander}^{(1)*} + K_{reducer}^{(1)}) \times \left(\frac{A_{6\ inch}}{A_{4\ inch}}\right)^2$$

$$K = (0.32^{**} + 0.25^{**}) \times \left(\frac{21.15}{9.28}\right)^2$$

K = 2.96

f = .016[1]

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

$\rho$ = 7.65 lb/ft$^3$ [2] (saturated steam at 2500 psia)

A = 0.147 ft$^2$

The flow pressure difference is,

$$\Delta P_F = \frac{(2.96 + .016 \times 289.8)(1.11 \times 104.4)^2}{64.4 \times 7.65 \times .147^2 \times 144}$$

$\Delta P_F$ = 66.5 psi

---

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

**Based on area ratio of $\frac{9.28}{21.15}$ = 0.44.

(2) Transient Acoustic Wave Amplitude

Since $T_{op} < \frac{2L}{a}$, the acoustic wave amplitude is,

$$\Delta P_{AW} = \frac{a\ (C\dot{M})}{g_c A} + \frac{(C\dot{M})^2}{2g_c \rho A^2}$$

$$\Delta P_{AW} = \frac{1100 \times (1.11 \times 104.4)}{32.2 \times .147 \times 144} + \frac{(1.11 \times 104.4)^2}{64.4 \times 7.65 \times .147^2 \times 144}$$

$$\Delta P_{AW} = 195.8 \text{ psi}$$

(3) Plant-Specific Transient Pressure Difference

The plant-specific pressure difference for valve opening is,

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

$$\Delta P = 66.5 + 195.8 = 262.3 \text{ psi}$$

(4) Plant-Specific Steady-State Flow Pressure Difference

The steady-state flow pressure difference for valve opening is,

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

$$\Delta P_F = \frac{(2.96 + 0.16 \times 289.8)\ (1.11 \times 104.4)^2}{64.4 \times 7.65 \times .147^2 \times 144}$$

$$\Delta P_F = 66.5 \text{ psi}$$

(5) Plant-Specific Pressure Difference for Plant versus Test Evaluation (Opening)

Based on the above, the controlling pressure difference is the transient pressure difference, i.e., 262.3 psi.

b. Valve Closing

From Table B-2, the closing time is,

$$T_{cL} = .016 \text{ sec}$$

Also,

$$\frac{2L}{a} = \frac{2 \times 33.6 \text{ ft}}{1100 \text{ft/sec}} = .061 \text{ sec}$$

Therefore,

$$T_{cL} < \frac{2L}{a}$$

(1) Transient Flow Pressure Difference

Since $T_{cL} < \frac{2L}{a}$, the flow pressure difference is,

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

All parameter values are the same as for valve opening above, except,

$$C = 0.69$$

The flow pressure difference is,

$$\Delta P_F = \frac{(2.96 + .016 \times 289.8)(.69 \times 104.4)^2}{64.4 \times 7.65 \times .147^2 \times 144}$$

$$\Delta P_F = 25.7 \text{ psi}$$

(2) Transient Acoustic Wave Amplitude

Since $T_{cL} < \frac{2L}{a}$, the acoustic wave amplitude is,

$$\Delta P_{AW} = \frac{a\ (C\dot{M})}{g_c A} + \frac{(C\dot{M})^2}{2g_c\ \rho A^2}$$

$$\Delta P_{AW} = \frac{1100\ (.69 \times 104.4)}{32.2 \times .147 \times 144} + \frac{(.69 \times 104.4)^2}{64.4 \times 7.65 \times .147^2 \times 144}$$

$$\Delta P_{AW} = 119.6 \text{ psi}$$

(3) Plant-Specific Transient Pressure Difference

The plant-specific pressure difference for valve closing is,

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

$\Delta P = 25.7 + 119.6 = 145.3$ psi

(4) Plant-Specific Steady-State Flow Pressure Difference

The steady-state flow pressure difference for valve closing is the same as that for valve opening (66.5 psi).

(5) Plant-Specific Pressure Difference for Plant versus Test Evaluation (Closing)

Based on the above, the controlling pressure difference is the transient pressure difference, i.e., 145.3 psi.

c. Comparison of In-Plant Valve Opening/Closing Pressure Differences to those Computed for Specific Test Configurations

Assume that the valve manufacturer (Crosby) indicates that the performance of the 4M16 valve should be evaluated based on test results obtained with the 6M6 valve. For valve opening, the plant pressure difference of 262.3 psi is essentially equal to the pressure difference of 263 psi calculated for the test valve with piping "G" (see Table B-3). For valve closing, the plant pressure difference of 145.3 psi is less than the pressure difference of 181 psi calculated for the test valve. Therefore, the performance of the 4M16 plant valve can

be evaluated based on the test performance of the 6M6 valve with piping "G". (Provided the ring setting and back pressure criteria in Appendix D are also satisfied).

2. Problem #2

Following is a calculation of the plant-specific pressure difference for the assumed safety valve/inlet piping configuration shown in Figure B-2.

a. Valve Opening

From Table B-2, the opening time is,

$$T_{op} = .015 \text{ sec}$$

Also,

$$\frac{2L}{a} = \frac{2 \times 3.0 \text{ ft}}{1100 \text{ ft/sec}} = .005 \text{ sec}$$

Therefore,

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

(1) Transient Flow Pressure Difference

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

$$\Delta P_F = \frac{(K + \frac{fL}{D})(C\dot{M})^2 \ (\frac{2L}{aT})^2}{2g_c \ \rho A^2}$$

where,

$$\dot{M} = \frac{323{,}000 \text{ lb/hr}}{3600 \text{ sec/hr}} = 89.7 \text{ lb/sec}$$

C = 1.11 (from Table B-2)

k = 0

f = .019 (1)

$$\frac{L}{D} = \frac{3.0}{.177} = 16.9$$

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

$A = .025 \text{ ft}^2$

The flow pressure difference is,

$$\Delta P_F = \frac{(.019 \times 16.9)(1.11 \times 89.7)^2 \left(\frac{2\text{x}3.0}{1100\text{x}.015}\right)^2}{64.4 \times 7.65 \times .025^2 \times 144}$$

$$\Delta P_F = 9.5 \text{ psi}$$

(2) Transient Acoustic Wave Amplitude

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

$$\Delta P_{AW} = \frac{2L(C\dot{M})}{g_c AT} + \frac{(C\dot{M})^2 \left(\frac{2L}{aT}\right)^2}{2g_c \ \rho A^2}$$

$$\Delta P_{AW} = \frac{2\text{x}3.0 \ (1.11\text{x}89.7)}{32.2\text{x}.025\text{x}.015\text{x}144} + \frac{(1.11\text{x}89.7)^2 \left(\frac{2\text{x}3.0}{1100\text{x}.015}\right)^2}{64.4\text{x}7.65\text{x}.025^2\text{x}144}$$

$$\Delta P_{AW} = 373.1 \text{ psi}$$

(3) Plant-Specific Transient Pressure Difference

The plant-specific pressure difference for valve opening is,

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

$$\Delta P = 9.5 + 373.1 = 382.6 \text{ psi}$$

(4) Plant-Specific Steady-State Flow Pressure Difference

The steady-state flow pressure difference for valve opening is,

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

$$\Delta P_F = \frac{(.019 \times 16.9)(1.11 \times 89.7)^2}{64.4 \times 7.65 \times .025^2 \times 144}$$

$$\Delta P_F = 71.8 \text{ psi}$$

(5) Plant-Specific Pressure Difference for Plant versus Test Evaluation (Opening)

Based on the above, the controlling pressure difference is the transient pressure difference, i.e., 382.6 psi.

b. Valve Closing

From Table B-2, the closing time is,

$$T_{CL} = .012 \text{ sec}$$

Also,

$$\frac{2L}{a} = \frac{2 \times 3.0 \text{ ft}}{1100 \text{ ft/sec}} = .005 \text{ sec}$$

Therefore,

$$T_{CL} > \frac{2L}{a}.$$

(1) Transient Flow Pressure Difference

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

$$\Delta P_F = \frac{(K + \frac{fL}{D})\ (C\dot{M})^2 (\frac{2L}{aT})^2}{2g_c\ \rho A^2}$$

All parameter values are the same as for valve opening above, except,

$$C = .29$$

The flow pressure difference is,

$$\Delta P_F = \frac{(.019\text{x}16.9)\ (.29\text{x}89.7)^2 (\frac{2\text{x}3.0}{1100\text{x}.012})^2}{64.4\text{x}7.65\text{x}.025^2\text{x}144}$$

$$\Delta P_F = 1.0 \text{ psi}$$

(2) Transient Acoustic Wave Amplitude

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

$$\Delta P_{AW} = \frac{2L(C\dot{M})}{g_c AT} + \frac{(C\dot{M})^2\ (\frac{2L}{aT})^2}{2g_c \rho A^2}$$

$$\Delta P_{AW} = \frac{2\text{x}3.0(.29\text{x}89.7)}{32.2\text{x}.025\text{x}.015\text{x}144} + \frac{(.29\text{x}89.7)^2 \text{ x } (\frac{2\text{x}3.0}{1100\text{x}.012})^2}{64.4\text{x}7.65\text{x}.025^2\text{x}144}$$

$$\Delta P_{AW} = 92.9 \text{ psi}$$

(3) Plant-Specific Transient Pressure Difference

The plant-specific pressure difference for valve closing is,

$\Delta p = \Delta p_F + \Delta p_{AW}$

$\Delta p = 1.0 + 92.9 = 93.9$ psi

(4) Plant-Specific Steady-State Flow Pressure Difference

The steady-state flow pressure difference for valve closing is the same as that for valve opening (71.8 psi).

(5) Plant-Specific Pressure Difference for Plant versus Test Evaluation (Closing)

Based on the above, the controlling pressure difference is the transient pressure difference, i.e., 93.9 psi.

c. Comparison of In-Plant Valve Opening/Closing Pressure Differences to those Computed for Specific Test Configurations

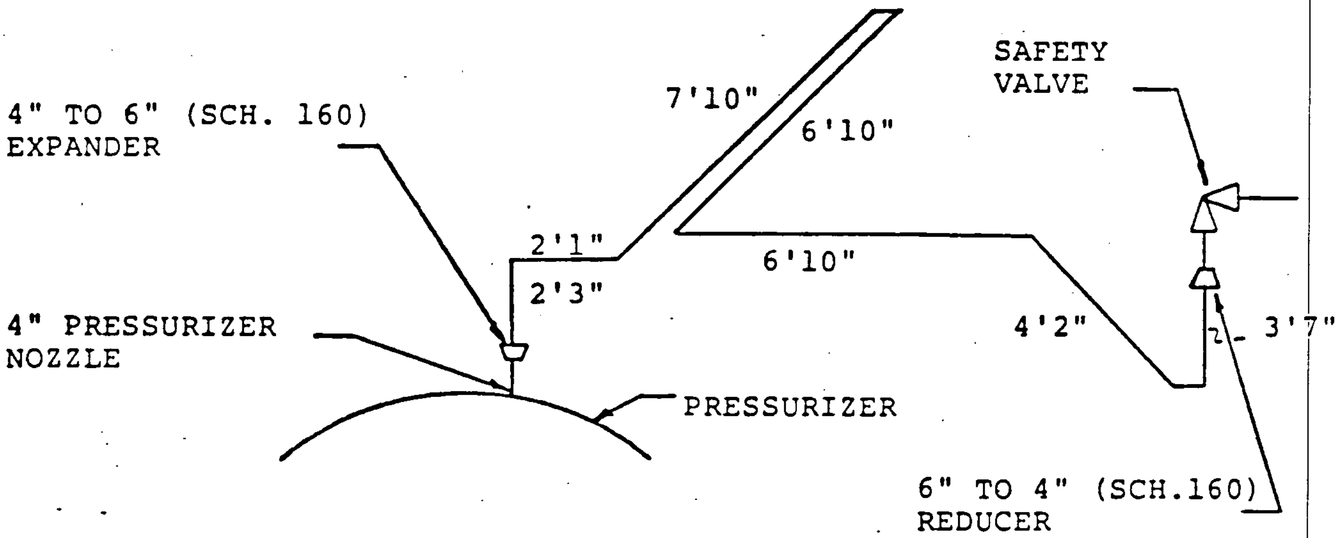
For valve opening, the plant pressure difference of 382.6 psi is less than the pressure difference of 643 psi calculated for the Dresser 31739A test valve with piping "D" (see Table B-3). For valve closing, the plant pressure difference of 93.9 psi is less than the pressure difference of 150 psi calculated for the test valve. Therefore, the performance of the 31739A plant valve can be evaluated based

on the performance of the 31739A test valve with piping "D". (Provided the ring setting and back pressure criteria in Appendix D are also satisfied.)

## 3. References

1. Flow of Fluids through Valves, Fittings and Pipe, Crane Co., Technical Paper No. 410, 1981

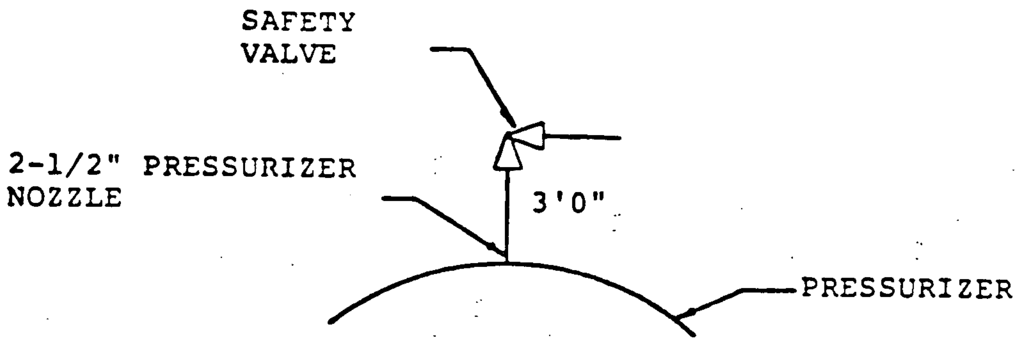
2. ASME Steam Tables, 1967




- CROSBY 4M16 SAFETY VALVE
- TOTAL PIPE LENGTH = 33' 7"
- PIPE DIAMETER = 6" SCH. 160 (5.189" INSIDE DIAMETER)
- FITTINGS
  - 6, 90° ELBOWS (L/D = 30 FOR EACH ELBOW)
  - 2, 45° ELBOWS (L/D = 16 FOR EACH ELBOW)
  - 1, 4" TO 6" EXPANDER (k=1.66, BASED ON 6" PIPE AREA)
  - 1, 6" TO 4" REDUCER (k=1.30, BASED ON 6" PIPE AREA)
- Flow Areas
  - 6" SCH. 160 PIPE -- 21.15 $IN^2$
  - 4" SCH. 160 PIPE -- 9.28 $IN^2$

FIGURE B-1

SAFETY VALVE INLET PIPING CONFIGURATION
- SAMPLE PROBLEM #1




- DRESSER 31739A SAFETY VALVE
- PIPE DIAMETER = 2-1/2" SCH. 160 (2.125" INSIDE DIAMETER)
- TOTAL PIPE LENGTH = 3'0"

FIGURE B-2

SAFETY VALVE INLET PIPING CONFIGURATION
- SAMPLE PROBLEM #2

TABLE B-1

SAFETY VALVE RATED CAPACITIES*

| Valve | Rated Capacity (lb/hr) |
| --- | --- |
| Dresser Valves | |
| 31709KA | 233,000 |
| 31739A | 323,000 |
| 31749A | 504,000 |
| 31759A | 423,000 |
| 31709NA | 550,000 |
| Crosby Valves | |
| 3K6 | 231,000 |
| 3K26 | 320,000 |
| 4K26 | 320,000 |
| 6K26 | 320,000 |
| 4MI6 | 376,000 |
| 6MI6 | 376,000 |
| 4M6 | 458,000 |
| 6M6 | 458,000 |
| 6N8 | 550,000 |

* From "Pressure Relieving Device Certifications," National Board of Boiler and Pressure Vessel Inspectors. (Rounded off to nearest 1,000 lb/hr.) Note that these capacities may differ from the capacities on the valve nameplate because of changes in valve rating rules from the time the valves were supplied.

TABLE B-2

VALVE OPENING AND CLOSING TRANSIENT FLOW PARAMETERS

| Valve | Valve Opening C | Valve Opening T (sec) | Valve Closing C | Valve Closing T (sec) |
|---|---|---|---|---|
| - All Dresser Valves | 1.11 | .015 | .29 | .012 |
| - Crosby Valves | | | | |
| 3K6 | 1.11 | .010 | .57 | .012 |
| All other valves | 1.11* | .010 | .69 | .016 |

VALVE STEADY-STATE FLOW PARAMETERS

| Valve | Valve Opening or Closing C |
|---|---|
| - All Dresser Valves | 1.11 |
| - All Crosby Valves | 1.11* |

* For Crosby 6M6 plant valves with ring settings the same as the 6M6 test "reference" ring settings, a value of 1.0 for C may be used.

TABLE B-3

INLINE PIPING PRESSURE DIFFERENCES FOR VALVE OPENING AND CLOSING

| Valve/Piping Configuration | Pressure Difference (psi) Opening | Closing |
|---|---|---|
| Dresser 31739A | | |
| - Piping"D" | 643 | 150 |
| - Piping "C" | 249 | 54 |
| Dresser 31709NA | | |
| - Piping "B" | 142 | 51 |
| Crosby 3K6 | | |
| - Piping "F" | 391 | 194 |
| - Piping "E" | 157 | 77 |
| Crosby 6M6 | | |
| - Piping "G" | 263 | 181 |
| Crosby 6N8 | | |
| - Piping "H" | 309 | 165 |

E. Summary of Tested Valve/Piping Configurations

Following are Tables B-4 through B-9 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 are mounted. The information contained in these tables is the same as the information contained in Tables 3.1.1.a through 3.6.1.a of Reference 1 (in Section V).

The transient upstream piping pressure differences associated with valve opening and closing for each test valve/inlet piping configuration are listed in Table B-3. Opening and closing times used to calculate the pressure differences are listed in Table B-2. These opening and closing times were established based on the times measured in the EPRI/PWR Safety and Relief Valve Test Program.

The valve opening and closing flow parameters provided in Table B-2 were determined from the CE facility test data as follows:

- Valve Opening - The valve opening (pop) time was the effective time for the valve disk to move from the closed position to the rated lift position. The flow rate constant was determined based on the flow rate measured at the end of the valve opening transient.

- Valve Closing - In the CE facility tests, all valves exhibited the same general behavior:

  - In the initial closure phase, the valve disk closed from the full lift position to a partial lift position over an extended period of time (several seconds). Since the resulting rate of change in valve flow rate with time ($\Delta\dot{M}/\Delta t$) was small, the resulting differential pressure developed in the inlet piping during this closure phase was small.

  - In the final closure phase, the valve disk closed from the partial lift position in a short time period (approximately 15 milliseconds). It was during this second closure phase that the largest inlet piping differential pressure was developed.

The flow parameters listed in Table B-2 were determined from the CE facility test data plots for the final valve closure phase. The closing time was the time for the valve disk to move from the partial lift position to the closed position. The flow rate constant was determined based on the ratio of the measured flow rate at the start of the final closure phase and the rated flow rate listed in Table B-1.

## TABLE 1

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

| Combination | Plant/System Operating Condition | Load Combination | Service Stress Limit |
|---|---|---|---|
| 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

| Combination | Plant/System Operating Condition | Load Combination | Service Stress Limit |
|---|---|---|---|
| 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/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.) 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 2

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

## PIPING

| Combination | Plant/System Operating Condition | Load Combination | Service Limit |
|---|---|---|---|
| 1 | Normal | N | A |
| 2 | Upset | $N + SOT_U$ | B |
| 3 | Emergency | $N + SOT_E$ | C |
| 4 | Faulted | $N + SOT_F$ | D |

## SUPPORTS

| Combination | Plant/System Operating Condition | Load Combination | Service Limit |
|---|---|---|---|
| 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 3

## DEFINITIONS 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.

## TABLE B-4

## 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. | BN-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

### 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 |

### 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 |

EPRI/CE SAFETY VALVE TEST PROGRAM

TABLE B-5

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

## Inlet Piping Configuration "A"

| | Length, in. | 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 |

## Inlet Piping Configuration "B"

| | Length, in. | 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 |

EPRI/CE SA[illegible] VALVE TEST PROGRAM

TABLE n-6

# 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.

## 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 |

## 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 |

EPRI/CE SAFETY VALVE TEST PROGRAM

TABLE B-7

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.

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 | 54 | 3.152 |
| Bends | 4-90$^\circ$ | 6 inches radius |
| Reducer | 4 | 3.152/2.624 |
| Inlet Flange | 7 | 2.624 |

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 |

EPRI/CE SAFETY VALVE TEST PROGRAM

TABLE B-8

SAFETY VALVE DESCRIPTION AND INLET PIPING CONFIGURATION

FOR THE CROSBY HB-BP-86 6M6 (LOOP SEAL INTERNALS)

## Valve Description

| | |
|---|---|
| Manufacturer | Crosby Valve and Cage Company |
| Type | Spring Loaded Safety Valve |
| Model No. | HB-BP-86 6M6 |
| Serial No. | N56964-00-0086 |
| Drawing No. | Crosby DS-C-56964 Rev. C |

Body Size (inlet/outlet) 6 in./ 6 in.

Bore Area 3.644 in.$^2$

Orifice Designation M

Design Set Point Pressure 2485 psig

Design Blowdown 5 percent

Rated Flow 420,006 lb/hr. Rated Lift 0.538 in.

Internals Type: Loop Seal

## Ring Setting Reference Position

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

## Inlet Piping Configuration "G"

| | Length, in. | I.D., in. |
|---|---|---|
| Nozzle | 17 | 6.813 |
| Venturi | 38 | 6.813 |
| Pipe | 13 | 6.813 |
| Reducer | 6 | 6.813/4.897 |
| Loop Seal | | |
| Straight | 48 | 4.897 |
| Bends | 2-180$^{0}$ | 9 in. radius |
| Reducer | Not Applicable | |
| Inlet Flange | 10 | 4.897 |

EPRI/CE SAFETY VALVE TEST PROGRAM

TABLE B-9

SAFETY VALVE DESCRIPTION AND INLET PIPING CONFIGURATION

FOR THE CROSBY HB-BP-86 6N8 (STEAM INTERNALS)

Valve Description

| | |
|---|---|
| Manufacturer | Crosby Valve and Gage Company |
| Type | Spring Loaded Safety Valve |
| Model No. | HB-BP-86 6N8 |
| Serial No. | N61894-00-0006 |
| Drawing No. | Crosby DSC- 61894 Rev. D |

Body Size (inlet/outlet) 6 in./ 8 in.
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

Ring Setting Reference Position:

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

Inlet Piping Configuration "H"

| | Length, in. | I.D., in. |
|---|---|---|
| Nozzle | 17 | 6.813 |
| Venturi | Not Applicable | |
| Pipe | 9 | 6.813 |
| Reducer | 6 | 6.813/5.189 |
| Pipe | 76 | 5.189 |
| Inlet Flange | 7 | 5.189 |

# 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).

# 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 and closing (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:

- <u>Test 1</u> -- 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.

- <u>Test 2</u> -- 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.

- <u>Test 3</u> -- This test is not directly applicable because the plant backpressure is greater than the test backpressure.

- <u>Test 4</u> -- This test is not directly applicable because the plant inlet piping pressure drop (and rise) are greater than the test inlet piping pressure drop (and rise).

- 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 and pressure rise due to valve closing less than the corresponding values 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.)

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.

TAB[illegible]-2

## SAMPLE TEST APPLICABILITY ASSESSMENTS ***

| | PLANT A | TEST 1 | TEST 2 | TEST 3 | TEST 4 | TEST 5 | TEST 6 |
|---|---|---|---|---|---|---|---|
| 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) (OR RISE) | 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).

# APPENDIX E

## LOAD COMBINATIONS AND ACCEPTANCE CRITERIA FOR THE SAFETY 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.

# APPENDIX F

## JUSTIFICATION OF RELIEF VALVE TEST CONDITIONS FOR PLANT COLD OVERPRESSURIZATION EVENTS

(Only for plants for which justification of conditions resulting from cold over-pressurization events is not provided in the "Test Conditions Justification Report" (Reference 3).)

- Maximum pressurizer pressure attained
- Possible fluid states
- Range of temperature for liquid passing through the PORV
  - Lower limit can generally be defined either by the Appendix G limiting temperature at PORV opening set point or review of plant operating/maintenance procedures
  - Upper limit can generally be defined as saturation temperature at PORV opening set point pressure

If the plant system has multiple or variable PORV set points as a function of reactor coolant system temperature, the range of liquid temperatures (in pressurizer) should be determined at each extreme of the possible pressure range.

Step 2

Provide a comparison of expected PWR plant conditions to those conditions under which the PORV design was tested. Specifically, show that:

- Tested steam pressure is greater than expected maximum plant steam pressure
- Tested liquid pressure is greater than expected maximum plant liquid pressure
- Tested range of liquid temperatures envelopes expected range for the plant (at the appropriate pressure levels)

A. Background

The NSSS vendor plant condition reports (References 4, 5 and 6) did not address conditions resulting from cold overpressurization events for some PWR plant units because,

- the vendor did not design the system, or
- the vendor had not completed the plant analysis as of the report publication.

Therefore, as part of their plant-specific evaluation, the affected utilities will have to provide justification that the conditions under which their relief valve design was tested are representative of those expected for such events. It is noted that the tested conditions were based on discussions with all utilities and are therefore expected to cover all participating PWR plant units.

B. Suggested Approach

It is suggested that the following approach be utilized by the affected utilities to justify that the relief valve test conditions are representative of the fluid conditions expected for plant cold overpressurization events.

- Step 1

  Determine the following based on review of the PWR plant-specific cold overpressurization analysis:

For plants with multiple/variable PORV set points, make the above comparisons at the upper and lower ends of the expected pressure range.

C. Sample Justification

Following is a sample justification using the procedure outlined in Section B above for an assumed set of PWR plant conditions.

- Plant"A" cold overpressurization protection system consists of the following:
  - Two Copes-Vulcan 17-4 PH plug and cage PORVs
  - PORV opening set points are reduced from 2350 to 400 psig whenever the reactor coolant system liquid temperature is below 300°F
- The plant cold overpressurization event analysis indicates that:
  - The design basis event is inadvertent actuation of the pressurizer heaters
  - The pressurizer generally has a steam bubble but can be water solid for low reactor coolant system temperatures
  - The PORV opens on saturated water at 400 psig (448°F)
  - The peak pressurizer pressure is 475 psig
- Based on the plant analysis, the expected ranges of fluid inlet conditions resulting from cold overpressurization events are as follows:

- Maximum pressure = 475 psig
- Actuation can be on steam or water
- Maximum liquid temperature = 448°F (saturation at 400 psig)
- Minimum liquid temperature = approximately 100°F (at temperatures below 100°F the reactor vessel head is generally off or the reactor coolant system is open for maintenance)

° The comparison of plant conditions to tested conditions for the Copes-Vulcan 17-4 PH plug and cage PORV is as follows:

| | In-Plant | Tested |
|---|---|---|
| Maximum pressure/steam | 475 psig | 2730 psig |
| Maximum pressure/liquid | 475 psig | 660 psig* |
| Maximum temperature at maximum pressure | 448°F | 442°F |
| Minimum temperature at maximum pressure | 100°F | 106°F |

° Based on the above comparison, it is concluded that the tested conditions are representative of expected conditions for cold overpressurization events in Plant "A".

* Maximum pressure tested over applicable liquid temperature range (i.e., 100 to 448°F)