Virginia Electric and Power Company
Richmond, Virginia 23261

W. L. Stewart
Vice President
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October 31, 1984

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
Attn: Mr. James R. Miller, Chief
Operating Reactors Branch No. 3
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Serial No. 107B
E&C/TLG:jdm:2004N
Docket Nos. 50-338
50-339
License Nos. NPF-4
NPF-7

Gentlemen:

VIRGINIA ELECTRIC AND POWER COMPANY
NORTH ANNA POWER STATION UNITS 1 & 2
NUREG-0737, ITEM II.D.1
PERFORMANCE TESTING OF RELIEF AND SAFETY VALVES
REQUEST FOR ADDITIONAL INFORMATION

In our letter dated May 1, 1984, Serial No. 107, on the above subject, we noted we were having our vendor (Westinghouse) and architect-enginee. (Stone & Webster) prepare the information requested by your February 8, 1984 letter.

Enclosure 1 entitled "Responses to USNRC Request for Additional Information TMI Action NUREG-0737 (II.D.1), Relief and Safety Valve Testing for North Anna Power Station Units 1 & 2 Docket Nos. 50-338 and 50-339," provides the additional information.

Very truly yours,

W. L. Stewart

cc: Mr. James P. O'Reilly
Regional Administrator
Region II
Atlanta, Georgia 30303

Mr. M. W. Branch
NRC Resident Inspector
North Anna Power Station

A046
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Enclosure 1

RESPONSE TO US NRC

REQUEST FOR ADDITIONAL INFORMATION

TMI ACTION NUREG-0737 (II.D.1)

RELIEF AND SAFETY VALVE TESTING

FOR

NORTH ANNA POWER STATION

UNITS 1 AND 2

DOCKET NOS. 50-338 AND 50-339

Question 1

The submittal does not include a discussion of consideration of single failures after the initiating events. NUREG 0737 requires selection of single failures that produce maximum loads on the safety and relief valves. Include a discussion describing how the single failure considerations are met.

Response

The limiting Condition II transient that incurs safety valve actuation is the loss of external load event (FSAR 15.2.7). The analyses assumed an initial core power of 102 percent of rated with no direct reactor trip (on turbine trip). In addition, the pressurizer spray and power-operated relief valves were assumed inoperable. The combined effect from these assumptions produced the greatest (fastest) reactor coolant pressurization rate.

As the peak pressure is observed within a few seconds of transient initiation, single failures within the engineered safeguards systems would have little, or no effect, on the pressurization rate or peak pressure observed.

Question 2

As pointed out in the plant specific submittal, results from the EPRI test on the Dresser 31739A safety valve indicates that the test blowdown exceeded the 5% value given in the valve specifications. If the expected plant blowdowns also exceed 5%, an increase in pressurizer water level could occur such that the water level may reach the safety valve inlet line and results in a steam-water flow situation. Also, the pressure might be decreased sufficiently so that adequate cooling might not be achieved. Blowdown for the North Anna 1 and 2 Dresser 31759A safety valve, at its current ring settings was not discussed. The submittal did state that the valve manufacturer (Dresser) and the NSSS supplier (Westinghouse) were reviewing the Dresser 31759A ring settings.

Please provide the recommended ring settings along with the expected blowdown and a discussion addressing the increase in pressurizer water level and the adequacy of core cooling.

Response

The recommended ring settings for North Anna 1 and 2 were derived from the methodology of Mr. A. Singh of EPRI. The method is described in Mr. Singh's ASME paper entitled "A Correlation for Safety Valve Blowdown and Ring Setting" presented 11-16-82 at the ASME Winter Annual Meeting in Phoenix, Arizona. North Anna Unit 1 was adjusted as closely as possible to these recommended settings in November 1982. North Anna Unit 2 was adjusted as closely as possible to these recommended settings in April 1983. The recommended settings adjust the blowdown of the (6) valves to an approximate and expected value of 12.2% blowdown. This blowdown value was selected because of its direct correlation to the EPRI test results and the conservativeness of its magnitude. The refueling outages were taken as an opportunity to make verification of ring settings and to increase the blowdown settings to a value which would clearly produce top safety valve performance. The recommended ring settings for all (6) North Anna 1 & 2 Dresser 31759A safety valves is as follows:

<u>upper ring</u> - 48 notches below uncovering the compensator parts.

<u>middle ring</u> - 55 notches below flush with the seat.

<u>lower ring</u> + 11 notches above flush with the seat.

For all (6) valves, the upper and middle ring setting values are the same as the recommended values. For the lower ring setting, each valve was set as closely as possible to the recommended values. Variation of the lower ring setting was permitted by Dresser procedure in order to maintain clearance between the disc holder and the lower ring. For Unit 1, the lower ring settings are A(+5), B(+10), C(+7). For Unit 2 the lower ring settings are A(+2), B(+11), C(-2).

A spectrum of analyses utilizing increasing blowdown and the limiting Condition II event was conducted within the WOG program. For these analyses, a reference four-loop plant was used (see Table 4-4 of WCAP-10105). Blowdowns analyzed were 0, 5, 10 and 14 percent. The results from these analyses show that for the reference plant, blowdowns of up to 14 percent have no significant effect on the outcome of the safety analyses, i.e., no safety limits are violated. Subsequent analysis on 3 loop plants provided similar results as those received on the 4 loop plant analyses.

Question 3

The inlet piping pressure drops for the Dresser 31739A EPRI test valves were compared to the calculated North Anna 1 and 2 Dresser 31759A inlet piping pressure drops. As stated in the submittal, the Dresser 31709NA pressure drop was not available. The Dresser 31739A pressure drop of the plant submittal, Table 2-3, was taken from Reference 8 of the submittal. Reference 8, "EPRI PWR Safety and Relief Valve Test Program Guide for Application of Valve Test Program Results to Plant Specific Evaluation," Interim Report, March 1982, was not available to EG&G for review. As a result, the method used to determine the pressure drops could not be verified. Provide a copy of the report and identify how the pressure drops were determined.

Response

The March 1982 revision of interim report "EPRI PWR Safety and Relief Valve Test Program Guide for Application of Valve Test Program Results to Plant Specific Evaluation" was the document in existence at the time the North Anna submittal was prepared. A copy of this report is enclosed for your review. The transient pressure drop for the inlet piping configuration is provided in Table B.1 of the report.

Question 4

The plant specific submittal did not discuss steam relief valve inlet conditions for the cold overpressure transient. If there is a low pressure steam inlet condition possible for the North Anna 1 and 2 relief valves, provide a discussion explaining how the high pressure steam test data bounds the low pressure steam condition.

Response

The North Anna 1 & 2 Relief Valve Cold Overpressure protection system operates to maintain pressure below the EPRI test conditions. The system limits the Reactor Coolant pressure to less than 505 psig for a temperature range of 100°F to 320°F for Unit 1 and 100°F to 340°F for Unit 2. The EPRI Cold Overpressure testing conditions therefore bound the North Anna Systems with a maximum test pressure of 665 psig for a temperature range of 100°F to 450°F.

Question 5

The test results of the Dresser 31739A safety valve and the one drained loop seal test of the Dresser 37109NA safety valve were used in the plant specific submittal to demonstrate that the North Anna 1 and 2 Dresser 31759A safety valve was bounded by the test valves. The plant submittal stated that EPRI data indicated that steam flow rates in excess of rated flows are attainable. In addition, the footnote to Table 4-3 of the submittal stated rate flow was achieved but not reported in the EPRI Test Report Tables. Review of the EPRI Report revealed that the flow was recorded for two of the reference tests for the Dresser 31739A valve but flow was not recorded for the one loop seal test of the Dresser 37109NA. Provide a discussion explaining how the limited data for the test valves were extrapolated to demonstrate the Dresser 31759A valve will achieve rated flow.

Repsonse

No extrapolation was conducted to demonstrate the Dresser 31759A valve will achieve rated flow. As discussed, the Dresser 31739A and Dresser 37109NA test valves were selected by EPRI to bound the North Anna safety valve. Successful completion of tests conducted on the selected valves is meant to bound and, therefore, demonstrate acceptability of the plant-specific valve. The EPRI test results demonstrate functionability of the Dresser design and, therefore, meet the intent of the NUREG requirement. Furthermore, demonstration that the Dresser design will pass rated flow is achieved through ASME Code testing conducted by Dresser.

Question 6

Thermal expansion of the pressurizer tank and inlet piping would be expected to induce loading on the inlet flange of a safety or relief valve at the time the valve is required to lift. Provide a discussion explaining how the effect that this loading would have on valve operability was considered.

Response

Bending moments were induced on the EPRI safety/relief test valves to demonstrate functionability of these valves under pipe loading such as deadweight, thermal, safety valve and relief valve thrusts. Induced bending moments for the Dresser 31739A test valve was 241,738 in-lbs. and for the Masoneilan relief valve of 57,000 in-lbs. A review has shown that the maximum predicted bending moments for North Anna Unit 2 of 165,460 in-lbs. for the Dresser safety valve and 32,280 in-lbs. for the Masoneilan relief valve are less than those induced during the EPRI test, thus demonstrating functionability of these valves as bounded by the tests conducted by EPRI.

For North Anna Unit 1 the calculated piping loads at the safety and relief valve inlets have been found to be lower than the EPRI test loads for similar valves shown in Attachment C.

Question 7

Blowdown and expected valve stability for the North Anna 1 and 2 Dresser 31759A safety valve at its current ring settings were not discussed. The plant specific submittal did state that the valve manufacturer (Dresser) and the NSSS supplier (Westinghouse) were reviewing the Dresser 31759A ring settings. At the completion of their review, provide the recommended ring settings along with the expected blowdown and a discussion of the effects on valve stability, rated lift and rated flow.

Response

The recommended ring settings and the resulting blowdown value are identified in the response to Item (2). Stable valve performance is expected for these very-conservative settings. These settings improve valve performance by decreasing the possibility of valve clatter and increase the possibility of achieving full lift and flow.

Question 8

During testing of the Masoneilan 20000 series PORV, stroke time was found to be sensitive to actuator supply line size. To achieve the 2 sec stroke time requirement, the line size was increased and the actuator supply pressure was increased to 60 psig. Review of the EPRI safety and relief valve selected and justification report for the Masoneilan PORV (Drawing A8329 Rev. B) indicated that a maximum of 55 psig is allowed to the actuator to prevent component damage. The North Anna Plant submittal stated that adjustments are made as required to the PORVs prior to plant operation to assure the stroke times meet the requirements. Provide a discussion of the action being taken to assure that the required stroke time will be achieved without potentially damaging components.

Response

Design changes have been implemented on the pressurizer power operated relief valves at North Anna to provide cold overpressure protection for the reactor coolant system. Design Change 78-44 modified the valve inlet ports and the associated solenoid valves to increase the openings from 1/4" to 1/2" diameter. An additional vent hole was added to the pneumatic actuators and the actuator diaphragms were changed to a stronger material to decrease the valve opening stroke time. The piping from the solenoid valves to the pneumatic actuators was replaced with 3/4" tubing. The nitrogen supply pressure for cold overpressure protection mode is regulated to 55 psig.

The combination of equipment modification, tubing size and nitrogen regulator pressure provide adequate assurance that the PORV's will open within the time requirements stipulated by Westinghouse. The cold overpressurization analyses requires the PORV's to open in less than or equal to 2.14 seconds. The PORV's at North Anna have been tested after maintenance by MMP-C-GV-1 and have been verified to open in $\leq$ 2.14 seconds in a dry, unpressurized condition.

In conclusion, the PORV's at North Anna have the proper nitrogen supply pressure and tubing diameter to provide adequate volumetric flow rate for a 2.14 second maximum opening time. The design modifications have been tested and verified that the appropriate open stroke times can be achieved.

Question 9

The Westinghouse 3GM88 EPRI test valve with a Limitorque SB-00-15 actuator successfully opened and closed on command only after the torque switch was set to the maximum of 3.75 +. The plant specific submittal stated that Westinghouse modified the 3GM88 block valve at North Anna to provide sufficient closing thrust. The details of the EMOV modification were not provided. Provide a discussion of modifications to the 3GM88 EMOV and the torque switch setting.

Response

Modification of the Westinghouse PORV block valves at North Anna consisted of modifications to the motor gear and pinion to provide the additional thrust required for closure and to electrically remove the torque switch from the actuator circuit during the final inch of valve stroke. Elimination of the torque switch during closure permits full use of available closing torque without the possibility of the valve stroke being terminated prior to full closure. Motor cut-out is then achieved by limit switch as the valve disc contacts the valve seat.

Question 10

The Westinghouse inlet fluid conditions report stated that liquid flow could exist through the PORV for the FSAR feedline break event and the extended high pressure injection event. Liquid PORV flow is also predicted for the cold over pressurization event. The EPRI/Marshall Block Valve Test Program did not test the block valves with fluid media other than steam. Since it is conceivable that the EMOV could be expected to operate with liquid flows, discuss EMOV block valve operability with expected liquid flow conditions. If the Westinghouse Gate Valve Closure Testing Program Report is used to demonstrate EMOV operability for liquid flow for the 3GM88 valve, provide a discussion of the test data.

Response

In a June 1, 1982 letter from R. C. Youngdahl to Mr. H. Denton, several block valve test submittals were made which included an explanation as to why block valve tests beyond the Marshall tests were not considered necessary, as well as an EPRI summary report covering Westinghouse gate valve closure testing. The Westinghouse report, transmitted to the NRC by the Youngdahl submittal, also includes a section on friction testing of stellited seating parts. Friction testing done by Westinghouse on stellite test specimens (note the Velan valve also has stellite seats) indicates that over the initial 200 cycles of testing, water test specimen friction factors increased from as low as 0.12 until a level of 0.4 to 0.75 is reached. With 550°F steam, the friction factor starts in the 0.5 to 0.6 range (higher than the water tests) and drops to approximately 0.35 over the 200 cycle range. Considering the 21 test cycles completed at Marshall Steam Station, and in view of the above frictional data, the thrust required to cycle the valve during the steam tests would be similar to that if the test medium were water.

Question 11

The plant specific submittal stated that the installed Velan block valves were similar to the Velan block valve tested. However, the North Anna 1 and 2 Velan block valve model number and actuator RPM differ from the test block valve. discuss the design differences and any effects they may have on block valve operability.

Response

Information provided by EPRI with regard to description of the Velan block valve used for testing was reprinted from the EPRI-Marshall block valve report to the North Anna plant specific submittal. A review of the test valve drawing (Velan drawing 88425, Rev. B) shows the model number to be the same as the North Anna block valve, B10-354B-13MS. The two valves, therefore, must be similar in design. As for the actuator motor RPM, internal gearing of the actuator is sized to provide proper valve stroke times and stem thrusts, thus making the North Anna block valves similar in design to the Velan test valve.

QUESTION: 12. The submittal indicates that analyses of the safety and relief valve piping system are in progress or completed. The information received thus far contains no presentation of these analyses. A detailed description of the methods and computer programs used to perform the thermal hydraulic analysis should be provided when available. This should identify parameters used in the thermal hydraulic analysis such as timestep, valve flow area, peak pressures and pressurization rate, node spacing, and valve opening times and should discuss rational for their selection. For loop seal cases, the assumed water and temperature distribution in the upstream and downstream piping at the time of valve popping should be given and the development of this distribution explained. Further, the method used for treating valve resistance in the thermal hydraulic analysis should be presented and the flow rates corresponding to the resistances used should be given. Whether the flow rates through the safety valves were based on an ASME Code derating of the safety valves should be explained. A computer printout containing input and output from the thermal hydraulic analysis on a problem such as the locked rotor accident case should be provided.

RESPONSE: (Unit 1) The thermal hydraulic analysis was performed by using the Stone & Webster Engineering Corporation (SWEC) proprietary computer code-WATSLUG. The method and adequacy of this WATSLUG program are detailed in Attachment A which contains general description and verification against RELAP5/MOD1 and EPRI test results. The flow area of 2.074 in.^{2} for relief valve and 3.341 in.^{2} for safety valve were obtained from the manufacturers while opening time of 1.5 seconds for relief valve and 0.015 second for safety valve were based on EPRI test data for the similar valves. Node spacing and time step are parameters applicable to RELAP and are not relevant to WATSLUG Program used. Pressurizer peak pressure of 2575 psia and pressurization rate of 54 psi/sec were selected for loss of load transient from the Westinghouse specification G-678838, Rev. 2 (see Attachment B for loss of load transient taken from W specification). Initially, the water slug average temperatures were approximately 190°F for relief valve and 400°F for safety valve based on calculation and EPRI Test No. 917 for a hot water seal. The downstream piping was assumed initially to be under ambient conditions. Valve resistance in the thermal hydraulic analysis is considered by treating the valve as an orifice for water flow and as a nozzle for steam flow. The steam flow rate corresponding to the resistance used was 210,000 lbm/hr for relief valve and 380,000 lbm/hr for safety valve at set pressures of 2335 psig and 2485 psig, respectively, with 3 percent accumulation. The locked rotor accident case was considered in the analysis by comparison with other transients that could actuate the relief and safety valves. The loss of load case was selected for the analysis on the basis that it is postulated in the W specification to occur 80 times while the faulted cases of feedwater line break, reactor coolant pump locked rotor, and control rod ejection are postulated to occur only once each. The most rapid pressurizer rise rate occurs with control rod ejection (470 psi/sec rise rate) which our analysis shows will create lower piping forces than the loss of load transient does due to higher safety valve backpressure caused by the incomplete relief valve slug discharge event for the locked rotor case the pressurizer rise rate of 107 psi/sec indicated in the W Specification G678838 Rev. 1 (Attachment B) or 216 psi/sec indicated in EPRI S/RV Test Program EPRI NP-2047LD Volume 3, Table 5.5 will create forces within 3 percent of those predicted for the loss of load case.

Response (Unit 2)

The adequacy of the thermal-hydraulic analyses can be verified by the comparison of analytical and test results for thermal hydraulic loadings in safety valve discharge piping for EPRI tests 908 and 917 presented in the submittal. In that evaluation, node spacing and time-step size were selected on the basis of stable solutions of the characteristic equations and matching of the test data. The safety valve full open flow area of 0.022 ft^2 was used in the model. This area is slightly smaller than the Crosby M-orifice area of 0.025 ft^2 for the tested valve, but resulted in a good analytical match of the tested fully open valve flow rate. Appropriate water temperatures were used. All pertinent data, including friction factors, loss factors and flow areas were based upon representative calculations and the system layout. Modeling of the water was conducted with the water seal upstream of the valves prior to transient initiation. At time $=0^+$, the transient was initiated and the slug position was analytically calculated during and subsequent to valve opening.

The North Anna Unit #2 Plant specific thermal-hydraulic analysis was conducted based upon the same approach as used for the comparison to test data. Node spacing and time-step size were utilized consistent with values utilized in the comparison. Valve flow areas were selected based upon actual valve data with appropriate margins applied to account for flow rate uncertainties. Analyses performed assumed a 100 percent linear safety valve opening time (0.040 seconds) with the pressurizer conditions held at initial valves. All pertinent data, including friction factors, loss factors and flow areas were based upon representative calculations and the system layout. Modeling of the water slug from (a) temperature profile, (b) initial location, and (c) movement post-transient initiation viewpoint was consistent with the comparison study. The submittal discussed the loop seal temperature profiles. Choked flow is checked internally and automatically every time-step to ensure the proper formulation is applied at every flow path.

Safety and relief valves are modeled as two-way junctions. The pressure drop across the valve, provided the system is sub-cooled is given by:

$$\Delta P = C_D \rho v^2$$

Where ΔP = pressure drop

C_D = Discharge coefficient = f(Cv)

ρ = fluid density

v = velocity through the valve

In the case of choking at the valve, the velocity at the valve orifice area is set at the sonic velocity. Upstream and downstream boundary conditions are iteratively set to conserve mass and energy. Choked flow is internally checked to ensure the proper formulation is applied.

The maximum expected steam flow rate through the Masoneilan PORV's, the valves on North Anna Unit #2, is 210,000 lb/hr at approximately 2350 psia. Values of 228,600 and 230,400 lb/hr, at 2745 and 2780 psia respectively (both tests conducted at pressures above the valve set pressure) were observed in EPRI/Wyle Tests (EPRI Report NP-2670-LD, Volume 6, "EPRI/Wyle Power Operated Relief Valve Phase III Test Report Volume 6: Summary of Phase III Testing of the Masoneilan Relief Valve", October, 1982). To account for all uncertainties and tolerances in the valve flow rate, the valve flow area was adjusted accordingly. The minimum analytically calculated steam flow of each of the two PORV's is greater than 255,000 lb/hr. This is a flow of 123% of rated. The analysis assumed a 100% linear PORV valve opening in 1.00 seconds. Full open times, based upon tests, averaged 2.77 seconds with a minimum value of 1.64 seconds for opening on steam.

The nominal steam flow rating for the Dresser Safety Valves at 2575 psia is 388,000 lb/hr. As with the PORV's, to ensure that adequate margin existed in the valve flow rate to account for all uncertainties and tolerances, the analytically calculated steam flow was checked prior to finalizing this phase of the overall effort. The flow used in the analysis (565,000 lb/hr) was 145% of rated. The safety valves were presumed to open fully in 0.040 seconds. This is based upon an effective linear opening time. This valve opening time as illustrated by test 917 and 908 comparisons, results in a very good data match.

As discussed in the submittal, the computer code ITCHVALVE was utilized to perform the transient hydraulic analysis for the system. This program utilizes the Method of Characteristics approach to generate fluid parameters as a function of time. A discussion of the method of characteristics solution technique is presented in the following articles:

1. A. C. Spencer and S. Nakamura, "Implicit Characteristic Method for One-Dimensional Fluid Flow", ANS Transaction, Volume 17, P. 247, November, 1973.

2. S. Nakamura, M. A. Berger and A. C. Spencer, "Implicit Characteristic Method for One-Dimensional Fluid Flow", Proceedings of the Conference on Computational Methods in Nuclear Engineering, Conference 75040, National Technical Information Service, Springfield, VA. 1975.

A. C. Spencer is a full time Westinghouse employee who was and is directly involved in the development of the ITCHVALVE Computer Program.

Once the time-history fluid properties were available, the properties were utilized in determining the forcing functions. Unbalanced forces were calculated for each straight segment of pipe from the pressurizer to the relief tank. A discussion of the methodology for generating the thermal hydraulic forcing functions and a comparison of analytically determined hydraulic force results to test data is presented in the following article:

L. C. Smith and K. S. Howe, "Comparison of EPRI Safety Valve Test Data with Analytically Determined Hydraulic Results", The International Conference on Structural Mechanics in Reactor Technology, Chicago, Illinois, August 22-28, 1983, Volume F, 2/6, pp. 89-96.

L. C. Smith and K. S. Howe are full time Westinghouse employees who were and are involved in pressurizer safety and relief valve and thermal hydraulic issues.

Because of the proprietary nature of the ITCHVALVE computer program, a descriptive report is not supplied at this time. However, if so desired, this information could be reviewed at the Westinghouse facility in Pittsburgh.

QUESTION: 13. As with the thermal hydraulic analysis, a detailed description of the methods and computer programs used to perform the structural analysis of the discharge piping should be provided. The methodology for calculating forcing functions and applying the forces to the structural model should be explained. The methods used to model supports, the pressurizer and relief tanks and connections, and the portions of the safety/relief valves lying off the main pipe axis should also be described. Other parameters such as lumped mass spacing, solution time step, damping, and cutoff frequency should be identified and rationale for their selection given. Further, the load combination and corresponding allowable stress limits used should be explained. The governing codes and standards used to determine piping and support adequacy should be identified. Finally, results from the analysis should be presented and a safety evaluation of the safety/relief valve piping system should be made.

RESPONSE:
(Unit 1)

The structural analysis of the upstream and downstream piping due to safety valve discharge was performed using SWEC's NUPIPE-SW computer program which performs an elastic evaluation of three-dimensional piping systems.

The basic method of analysis used in NUPIPE-SW is the finite element stiffness method. In accordance with this method, the continuous piping is mathematically idealized as an assembly of elastic structural members connecting discrete nodal points. Nodal points are placed in such a manner as to isolate particular types of piping elements such as straight runs of pipe, elbows, valves, etc, for which force-deformation characteristics can be categorized. Nodal points are also placed at all discontinuities such as piping supports, concentrated weights, branch lines, changes in cross section, and eccentric weights such as valve operators.

Loadings such as weights, equivalent thermal forces, and earthquake inertia forces are applied at the nodal points. Stiffness characteristics of the interconnecting members are related to the effective shear area and moment of inertia of the pipe. The stiffnesses of piping elbows and certain branch connections are modified to account for local deformation effects by the flexibility factors suggested in the ASME Section III.

The methodology used to calculate the forcing functions is described in the response to Question 12. The forcing functions are then applied to the appropriate piping segments and a time history modal superposition analysis is performed using NUPIPE-SW. The dynamic model is a lumped mass three-dimensional representation of the actual installation. Supports as well as piping are modeled in their true orientation which can either be coincident with global axes or skewed. Supports as well as connections to the pressurizer and relief tank are modeled as elastic springs in the NUPIPE-SW piping model.

The parameters for the time history analysis are selected to ensure sufficient accuracy and dynamic stability of the solution to the dynamic analysis of piping for fluid transient loadings. Typically, the model will contain at least three mass points between restraints active in the same direction. The piping geometry and large number of supports on the pressurizer safety and relief valve piping typically results in closely spaced mass points.

The cut-off frequency and mode are selected by a review of the piping geometry and system response characteristics recognizing the fact that the typical modes of excitation in this analysis are the higher frequency axial modes. The total analysis time and integration time steps for the analysis are selected based on a review of the input forcing function and to ensure a stable solution.

The damping values utilized for the analysis of the relief valve and safety valve loop seal clearing events are 1/2 percent and 1 percent of critical damping, respectively. These damping values are consistent with the values of the respective earthquakes (i.e., OBE and DBE) to which the relief valve and safety valve discharge cases are combined.

The piping stress analysis for the North Anna Unit 1 pressurizer safety and relief valve piping is performed in accordance with the USAS B31.7 Nuclear Power Piping Code 1969 Edition. The load combinations and allowables stress limits for the relief valve and safety valve discharge conditions are based on the UFSAR and EPRI recommendations. For Q1 (Class 1) piping, the equations are:

$$S_{LP} + S_{DW} + SRSS\ (S_{OBEI}, S_{OCC1}) \leq 1.5\ S_m$$

$$S_{LP} + S_{DW} + SRSS\ (S_{DBEI}, S_{OCC2}) \leq 2.25\ S_m$$

$$S_{LP} + S_{DW} + SRSS\ (S_{DBEI}, S_{OCC3}) \leq 3.0\ S_m$$

For Q2/3 (Class 2/3) piping, the equations are:

$$S_{LP} + S_{DW} + SRSS\ (S_{OBEI}, S_{OCC1}) \leq 1.2\ S_h$$

$$S_{LP} + S_{DW} + SRSS\ (S_{DBEI}, S_{OCC3}) \leq 1.8\ S_h$$

Where:

S_{LP} = Longitudinal pressure stress

S_{DL} = Deadload stress

S_{OBEI} = Seismic stress due to OBE inertia

S_{DBEI} = Seismic stress due to DBE inertia

S_{OCC1} = Stress due to relief valve discharge

S_{OCC2} = Stress due to safety valve discharge

S_{OCC3} = Larger of S_{OCC1} or S_{OCC2}

S_m = Allowable stress intensity at the design temperature

S_h = Allowable stress at the maximum operating temperature

The pipe supports are designed in accordance with the AISC Manual of Steel Construction 7th Edition. The loading conditions and allowables are as follows:

DW + THER + SRSS (OBET, OCC1) $\leq$ 1.33 (Basic Allowable)

DW + SRSS (DBEI, OCC3) $\leq$ 1.33 (Basic Allowable)

Where:

DW = Loads due to deadweight

THER = Loads due to thermal expansion

OBET = Operational basis earthquake (includes the effects of inertia and anchor movements)

DBEI = Design basis earthquake inertia

OCC1 = Loads due to relief valve discharge

OCC3 = Large of loads due to relief valve or safety valve discharge

The baseplate analysis will meet or exceed the requirements of I&E Bulletin 79-02.

The welded attachments to Class 1 pipe will be evaluated in accordance with the ASME code cases N122 and N391. Welded attachments to all other (non-Class 1) pipes will be evaluated per ASME code cases N318 and N392.

Response (Unit 2)

As noted in the submittal, the major structural analyses programs utilized in the static and dynamic analyses are described in WCAP-8252. This was reviewed and approved by the U. S. NRC (NRC letter, April 7, 1981 from R. L Tedesco to T. M. Anderson). A discussion of the methodology utilized in performing a safety valve discharge structural analysis and a comparison of analytical results to structural test results are presented in the following article:

L. C. Smith and T. M. Adams, "Comparison of Analytically Determined Structural Solutions with EPRI Safety Valve Test Results", 4th National Congress on Pressure Vessel and Piping Technology, Portland, Oregon, June 19 - 24, 1983 PVP-Volume 74, pp. 193 - 199.

Following is a discussion of key parameters used in the structural analyses of the thermal hydraulic events performed for the North Anna #2 Plant.

1. Damping: A conservative system damping of 2 percent was utilized. This is much lower than the actual expected value and is below the 10 percent damping used in the structural comparison to EPRI Tests 908 and 917.

2. Lumping: Lumped mass spacing was determined to ensure that all appropriate mode shapes were accurately represented.

3. Supports: The structural supports were modeled in sufficient detail to analytically represent the system. The shock suppressors and struts were modeled by inputting a stiffness in series with the piping. A linear overall system analysis was conducted.

4. Time Step: The integration time step is internally determined within the structural program and is based upon convergence criteria that results in stable solutions. The largest time step ever used could be 0.0001 second. The time step is automatically adjusted such that the relative error of each modal coefficient is at least less than 10^{-2}.

5. Cutoff Frequency: The cutoff frequency utilized in both the relief valve and safety valve discharge cases was approximately 1000 Hz.

The pressurizer was rigidly modeled for the thermal hydraulic analyses. The pressurizer nozzles and pipe connections were represented with appropriate pipe properties. Intensification at the nozzle to pipe welds were included. The downstream piping terminated at the relief tank inlet flange where the model was anchored.

The valve bonnet assemblies and the relief valve actuators were modeled as extended masses, displaced from the pipe centerline. The valves weight and center of gravity were selected from the valve drawings. The stem properties (diameter and thickness) were then selected to represent the valve frequency.

Program FORFUN was utilized to calculate the unbalanced wave forces for each segment of piping. The time-history hydraulic forces determined by FORFUN were then applied to the appropriate piping system lump mass points.

The axial extension from the balancing forces (opposing "blowdown" forces) on each end of the structural segment was considered in the FORFUN evaluation. However, this effect was determined to be negligible relative to the net unbalanced forces. Referring to structural analyses comparisons to test results for Tests 908 and 917, maximum support and pipe loads compared well with test results. Good comparisons of the maximum displacement values downstream of the safety value were also seen.

The submittal discusses:

1. The load combination and corresponding allowable stress limits

2. The governing codes and standards

3. The analyses results, and

4. The safety evaluation of the system

QUESTION: 14. The submittal should discuss whether multiple valve actuation conditions were considered in the analyses. The maximum loading on the piping typically occurs under a multiple valve actuation condition during which the valves open in sequence. The experience of EG&G Idaho indicates that the maximum loading occurs when the sequence of opening is such that the initial pressure waves from opening of the valves reach the common header downstream simultaneously. Thus, the method used to maximize the loading on the piping should be discussed.

RESPONSE: (Unit 1) All safety and relief valve discharge events are bounded by the respective loop seal clearing cases. The thermal hydraulic forcing functions for these cases are developed using SWEC's WATSLUG computer code which is described in the response to Question 12. The valve sequencing for the respective events are selected such that the water slugs from one, two or three safety valve loop seals, whichever creates the maximum force in particular segment of pipe are considered. They all join in the common discharge piping and continue through the system as a combined mass. In the case of the relief valve event, two water slugs will join, and for the safety valve event, three water slugs will join. The phasing of pressure waves are not significant for the water slug loop seal clearing event.

Response (Unit 2)

Two valve opening cases were addressed in the submittal, 1) the three safety valves opening simultaneously and discharging without PORV flow and 2) the two PORV's opening simultaneously without safety valve flow. The three safety valves are identical and have the same set pressure (± 1 percent). It was, therefore, assumed for the analysis that all three safety valves open simultaneously without PORV flow. Because of similarity, the two PORV's were also assumed to open simultaneously without safety valve flow.

Maximum common header (area of piping common to both safety and relief valve discharge piping) forces theoretically could be expected when valve sequencing is such that the initial pressure waves from valve opening reach a common downstream junction simultaneously. Based upon engineering judgment:

1. The simultaneous opening of the safety valves results in practically simultaneous peak loads at the safety valves common branch point. The peak forces occur within approximately.04 seconds of each other. As a result, no significant impact in the common header region, due to safety valve discharge, is expected, if the valve sequencing is adjusted such that the peaks of the initial pressure waves reach a common downstream header point simultaneously.

2. The total lengths of effective piping between each valve outlet and the common junction point are not exactly the same. The likelihood of the valve phasing being such to compensate for the different lengths is very small; therefore, the peaks of the initial pressure waves from valve opening, either safety or relief, would not reach a common downstream junction at exactly the same time.

3. There is a significant amount of piping and dynamic supports between the valve outlets and the common point. In the unlikely event that increased loadings from this common point to the relief tank were to occur, the effects would be limited primarily from near the common point to the relief tank. Significant isolation of the common region from the upstream region because of the support configuration exists. Therefore, the operability and integrity of the valves, the inlet lines to the valves, or the nozzles on the pressurizer would not be jeopardized.

Considerable margin exists between the conservatively calculated maximum stresses and the allowable stresses for the safety valve event. Tables 6-4 and 6-11 of the submittal report illustrate this for the upstream piping and Tables 6-8 and 6-15 demonstrate this for the downstream piping.

Question 15

Testing indicated that for loop seal discharge, liquid, or transition flow, valve instabilities occurred causing the valve to chatter or flutter at frequencies from 170-260 Hz. The instability caused large pressure transients on the safety valve inlet piping. The plant specific submittal presents the permissible pressures based on ASME Code allowable taken from Reference 9. Review of Reference 9 concluded that the peak internal pressure pulses were within acceptable limits. However, the submittal does not discuss the bending moments resulting from the piping dynamic effects due to the fluid pressure oscillations combined with other appropriate mechanical loads. Provide a comparison of the allowable piping moments with the computed moments resulting from the appropriate loading combinations with the piping dynamic effects included.

Response

The piping system response including the safety valve loop seal region is due to frequencies less the 100 Hz. The frequency of the forces and moments in the 170 - 260 Hz range potentially induced by the pressure oscillations is significantly greater than this frequency. The upper limit of significant frequency content for similar systems is much less than this (170 - 260 Hz) range. Industry data indicates that frequencies of 100 Hz or less are meaningful. The EPRI test data confirms this. Consequently no significant bending moment during the pressure oscillation phase of the transient will occur.

In the submittal, pressure stresses based upon a design pressure of 2485 psig were included with the bending moments resulting from the safety valve discharge piping loads. Because of the time phasing of the pressure oscillation (during water slug discharge through the safety valve) and the discharge piping loads (subsequent to water slug discharge thru the valve) this pressure term and moment term were not added. They do not occur coincidentally. A comparison of the intensified bending moments from the stress evaluation and the allowable moment presented in WCAP-10105 shows that all values are below the allowables. Specifically, the maximum allowable moment from Table 4-7 of WCAP-10105 for 6 inch schedule 160 piping for an internal pressure of 5000 psi is 516 in-kips. The bending moments for water slug discharge for the components (straight run, butt weld and elbow) listed in Table 6-11 of the submittal are 84.75, 84.74, 84.74 in-kips, respectively.

SAFETY EVALUATION QUESTIONS
NUREG 0737
NORTH ANNA UNITS 1 & 2

WATSLUG

ATTACHMENT A

1. General Description

The purpose of WATSLUG (Ref. 1) is to determine forcing functions on piping systems during water slug discharge events for subsequent input to piping dynamic analysis.

The analysis is based upon rigid body motion of the generally subcooled water slug and ideal gas representations of the steam or air using rigid column theory to facilitate tracking the several water-steam or water-air interfaces. The driving force is the steam pressure between the valve and the slug, less friction and other losses, and back pressure. Density changes due to possible local flashing of the water slug are considered. Having recourse to the control volume theory, the subsequent segment force calculation is carried out.

The input consists of complete piping system geometry, pipe dimensions, valve flow characteristics, valve opening time, detail upstream steam conditions, and initial downstream steam or air conditions, while the output contains forcing functions for each piping segment based upon flow velocities, pressures, and densities during the water slug discharge event. Forces are written on tape for direct input to NUPIPE-SW (ME-110). (Ref. 2).

2. Program Verification

The WATSLUG model of the test problem is diagrammed in Figure 3A.3.A-1 and the NUPIPE-SW model is diagrammed in Figure 3A.3.A-2. WATSLUG is verified by comparing the solution of this test problem to the results for the same problem obtained by an independent analytical approach (RELAP5/MOD 1, Ref. 3) as shown in Figures 3A.3.A-3 and 3A.3.A-4 and by comparison of predicted versus measured support reactions. NUPIPE-SW (ME-110) generated support reactions due to the WATSLUG forcing functions were compared with experimental measurements from a test run of this problem (EPRI Test 908, Ref. 3) as shown in Figures 3A.3.A-5 and 3A.3.A-6.

The WATSLUG generated forcing functions and the resultant NUPIPE-SW support reactions compare favorably with the RELAP5/MOD 1 predicted forcing functions and the EPRI measured support reactions, respectively.

3. References

1. "WATSLUG" (ME-212) computer code by J. S. Hsieh and D. A. Van Duyne, Ver. 0, Rev. 3, December 1982 and the related documentation calculation 576.470.1-NP(B)-038-FD. Rev. 2, "Water Slug Discharge in Piping System (WATSLUG) - Preproduction Version 3", dated March 3, 1982.

2. NUPIPE-SW, ME-110, V03,L14 (created 82.095), "Computer code for Stress Analysis of Nuclear Piping".

3. "Application of RELAP5/MOD 1 for calculation of Safety and Relief Valve Discharge Piping Hydrodynamic Loads", Interim Report, March 1982, by Intermountain Technologies, Inc., Idaho Falls, Idaho, Project Manager R. K. House.

TABLE 3A.3.A-1

INPUT DATA FOR WATSLUG *

PIPE NO.	TOTAL LENGTH (Ft)	INSIDE DIAMETER (Ft)	FRICTION FACTOR
1	16.125	0.408	0.015
2	12.563	0.5054	0.015
3	63.562	0.948	0.013

VALVE CHARACTERISTICS

ORIFICE AREA (Ft^2)	OPENING TIME (Sec)	DISCHARGE COEFFICIENT	FLOW RATE (lbm/sec)
0.0253	0.015	0.805	120.33

UPSTREAM STEAM CONDITIONS

PRESSURE (PSIA)	TEMPERATURE	DENSITY ($\frac{lbm}{Ft^3}$)	PRESSURE RISE RATE ($\frac{PSI}{Sec}$)
2690.	679°F (1139°R)	8.862	-40. **

DOWNSTREAM GAS CONDITIONS

PRESSURE (PSIA)	TEMPERATURE	DENSITY ($\frac{lbm}{Ft^3}$)
15.	80°F (540°R)	0.09975

WATERSLUG WEIGHT = 69.8 Lbs.

NOTES:

* SEE FIGURE 3A.3.A-1 FOR SKETCH OF WATSLUG MODEL

** PRESSURE IS DECREASING AFTER VALVE OPENS

TABLE 3A.3.A-2

INPUT DATA FOR NUPIPE-SW *

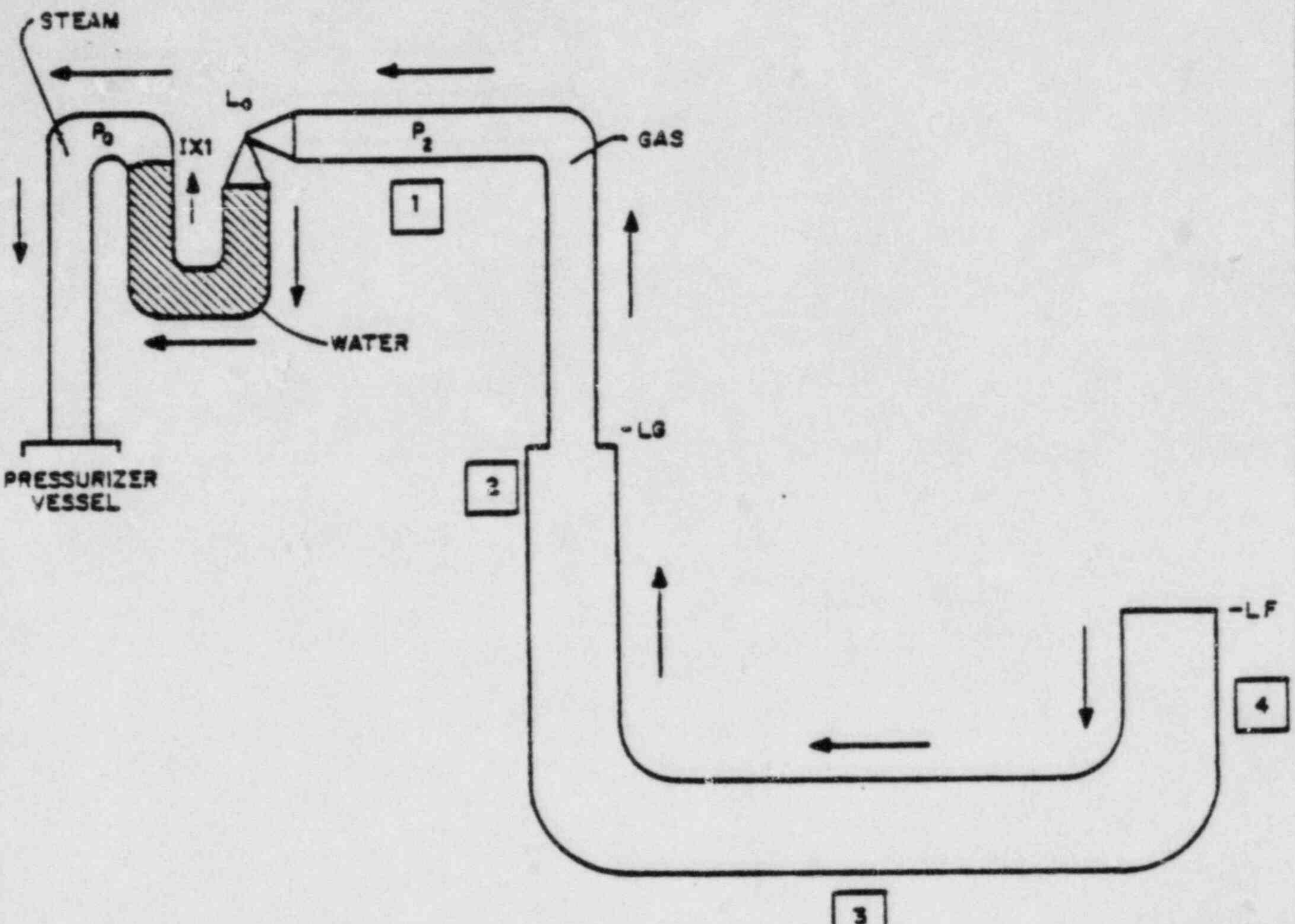
CUTOFF MODE	CUTOFF FREQUENCY	TIME STEP	INTEGRATION TIME	DAMPING RATIO
53	433 H_z	0.0009 Sec.	0.5 Sec.	10%

PIPE SECTION	TOTAL LENGTH (Ft)	OUTSIDE DIAMETER (IN)	THICKNESS (IN)	WEIGHT ($^{lb}/_{Ft}$)
1	4.73	8.625	0.906	74.71
2	12.31	6.625	0.864	53.16
3	12.43	6.625	0.28	18.97
4	69.0	12.75	0.688	88.60
5	1.1	12.75	1.5	--
6	1.0	8.625	0.322	28.55
7	0.83	6.625	0.432	28.57

$E_{HOT} = E_{COLD}$ = YOUNG's MODULUS OF PIPE = 28.3×10^6 PSI

NOTE:

* SEE FIGURE 3A.3.A-2 FOR SKETCH OF NUPIPE-SW MODEL



DISTANCES FROM PRESSURIZER VESSEL:

L_0 = SAFETY/RELIEF VALVE

LG = DOWNSTREAM AREA CHANGE

LF = PIPE EXIT

IX1 = TRAILING EDGE OF SLUG 1

← FORCING FUNCTION DIRECTION, +

☐ EPRI TEST (REF. 3) SEGMENT NO.

WATSLUG MODEL PIPE NUMBER

1 - PRESSURIZER TO L_0

2 - L_0 TO LG

3 - LG TO LF

FIGURE 3A.3.A - 1
WATSLUG MODEL OF EPRI SAMPLE PROBLEM

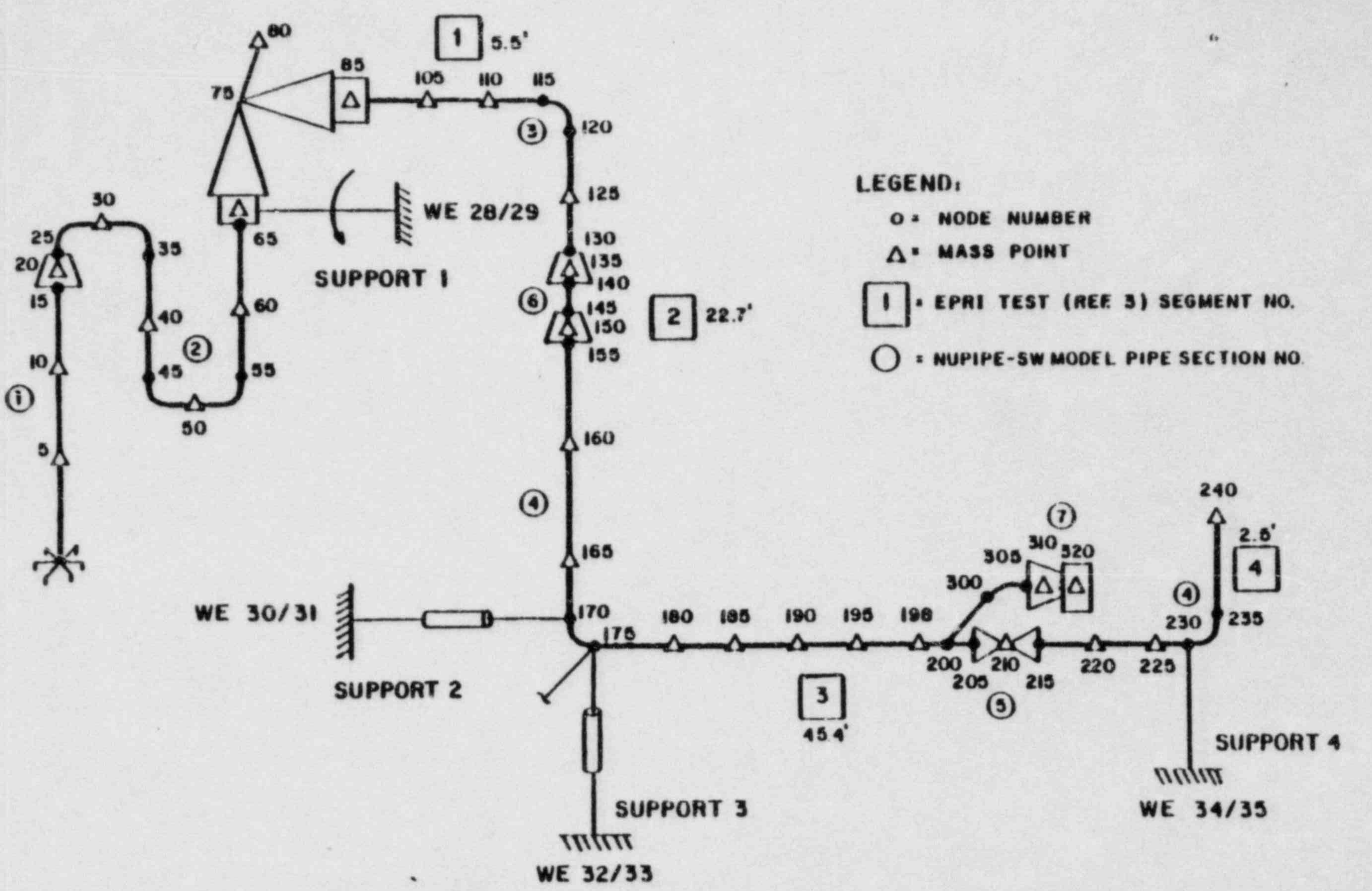


FIGURE 3A.3.A-2
NUPIPE-SW MODEL EPRI
SAMPLE PROBLEM

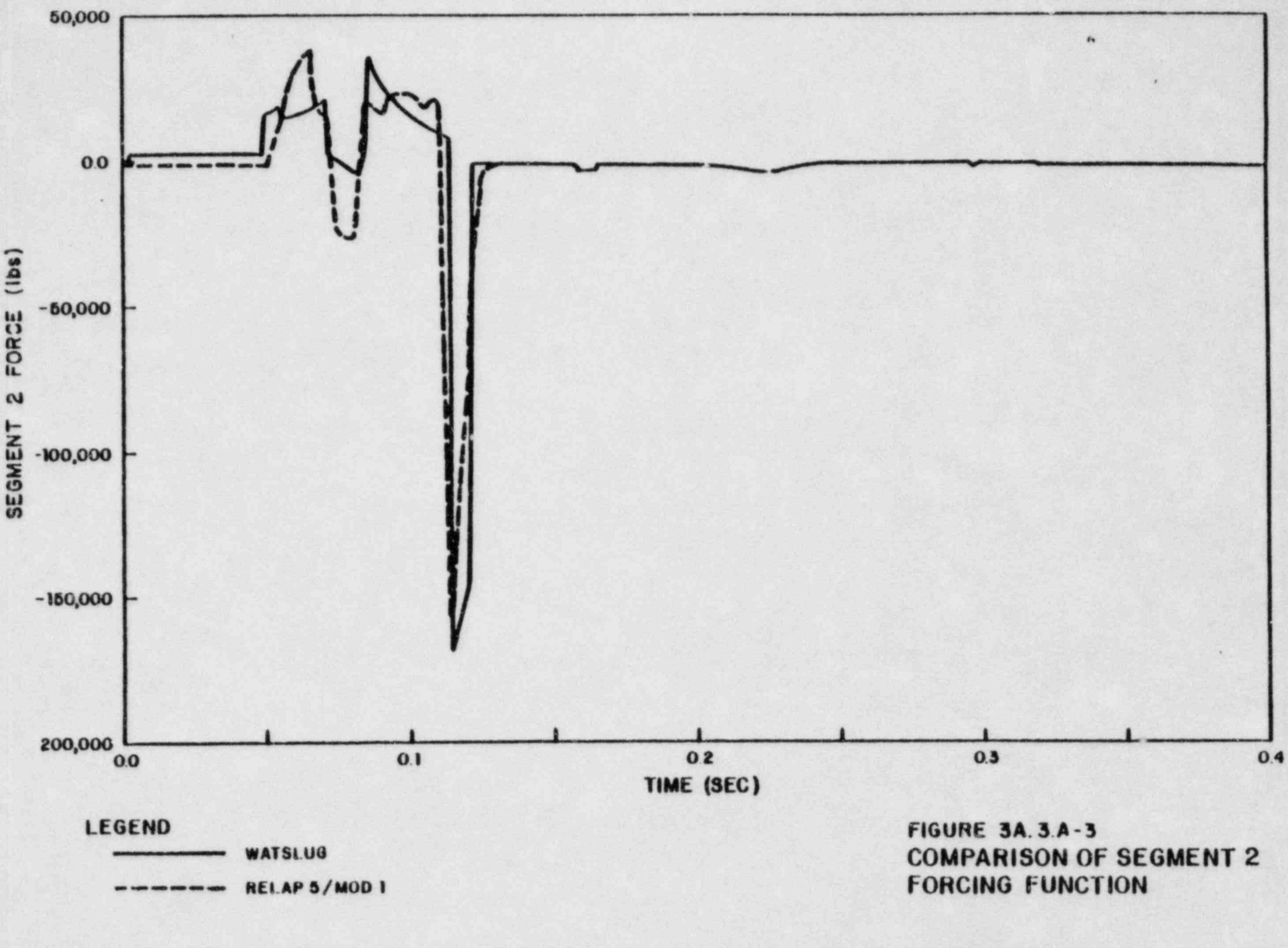


FIGURE 3A.3.A-3
COMPARISON OF SEGMENT 2
FORCING FUNCTION

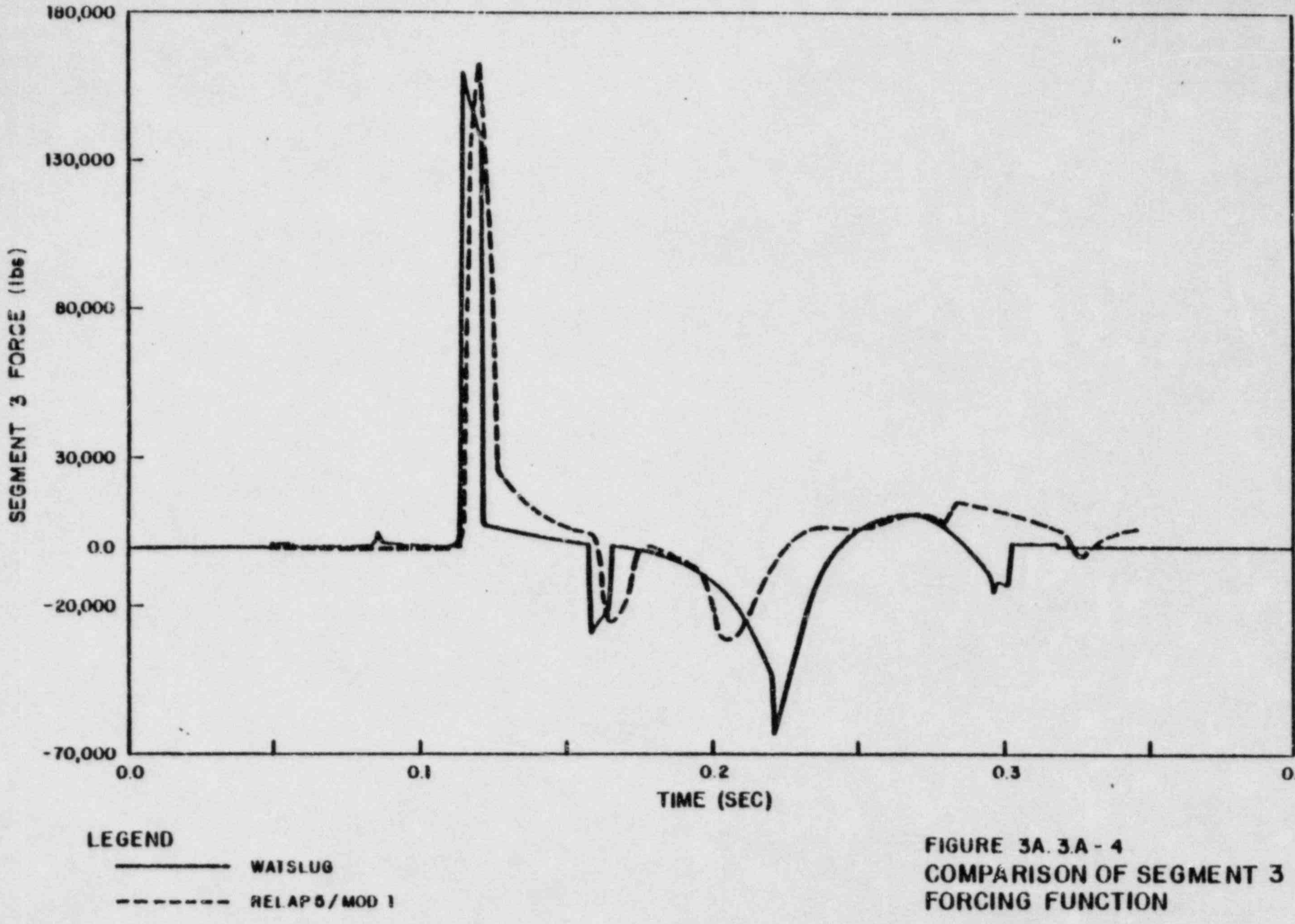


FIGURE 3A.3A-4
COMPARISON OF SEGMENT 3
FORCING FUNCTION

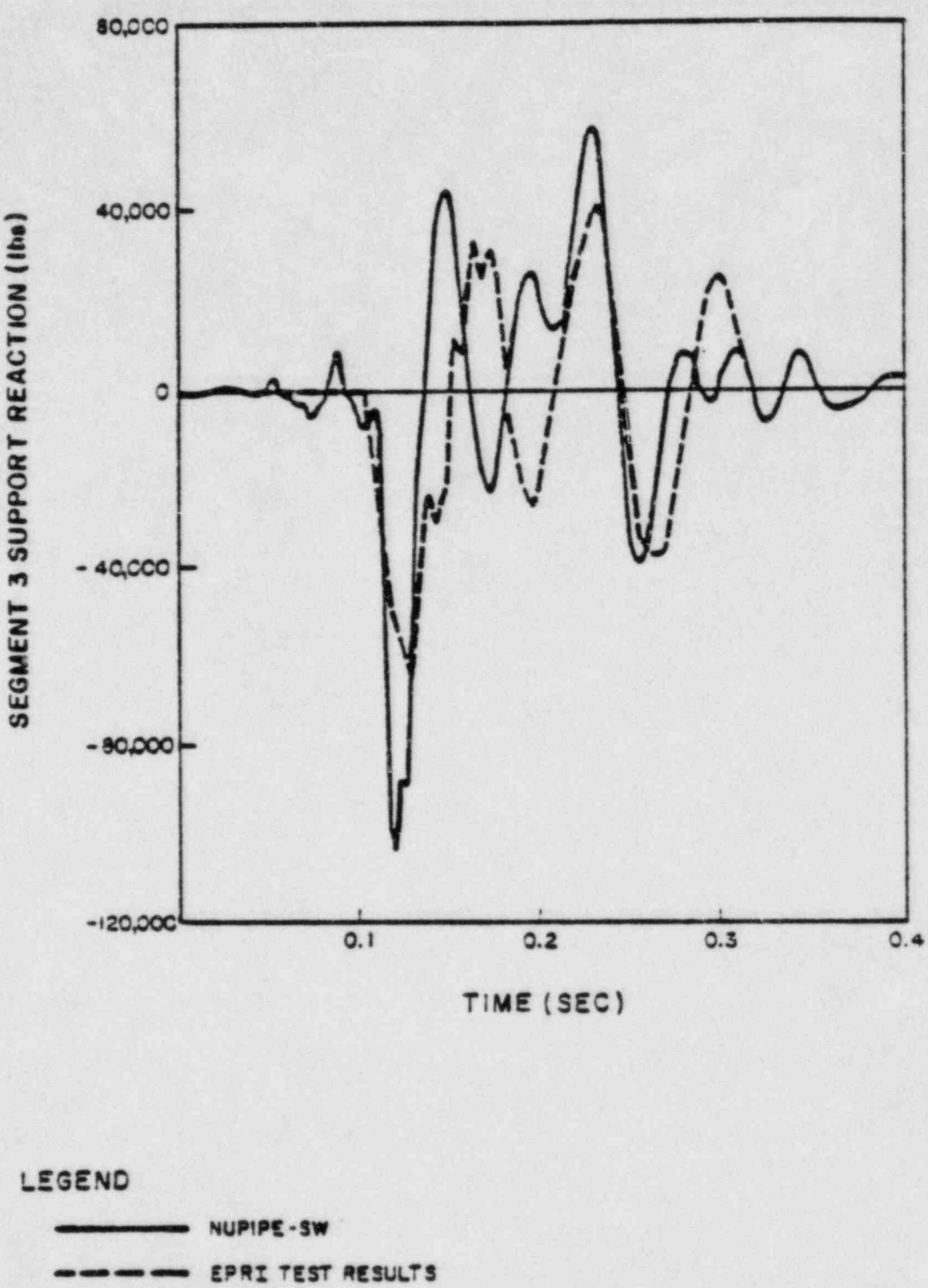


FIGURE 3A.3.A-5
COMPARISON OF SEGMENT 3
SUPPORT REACTION

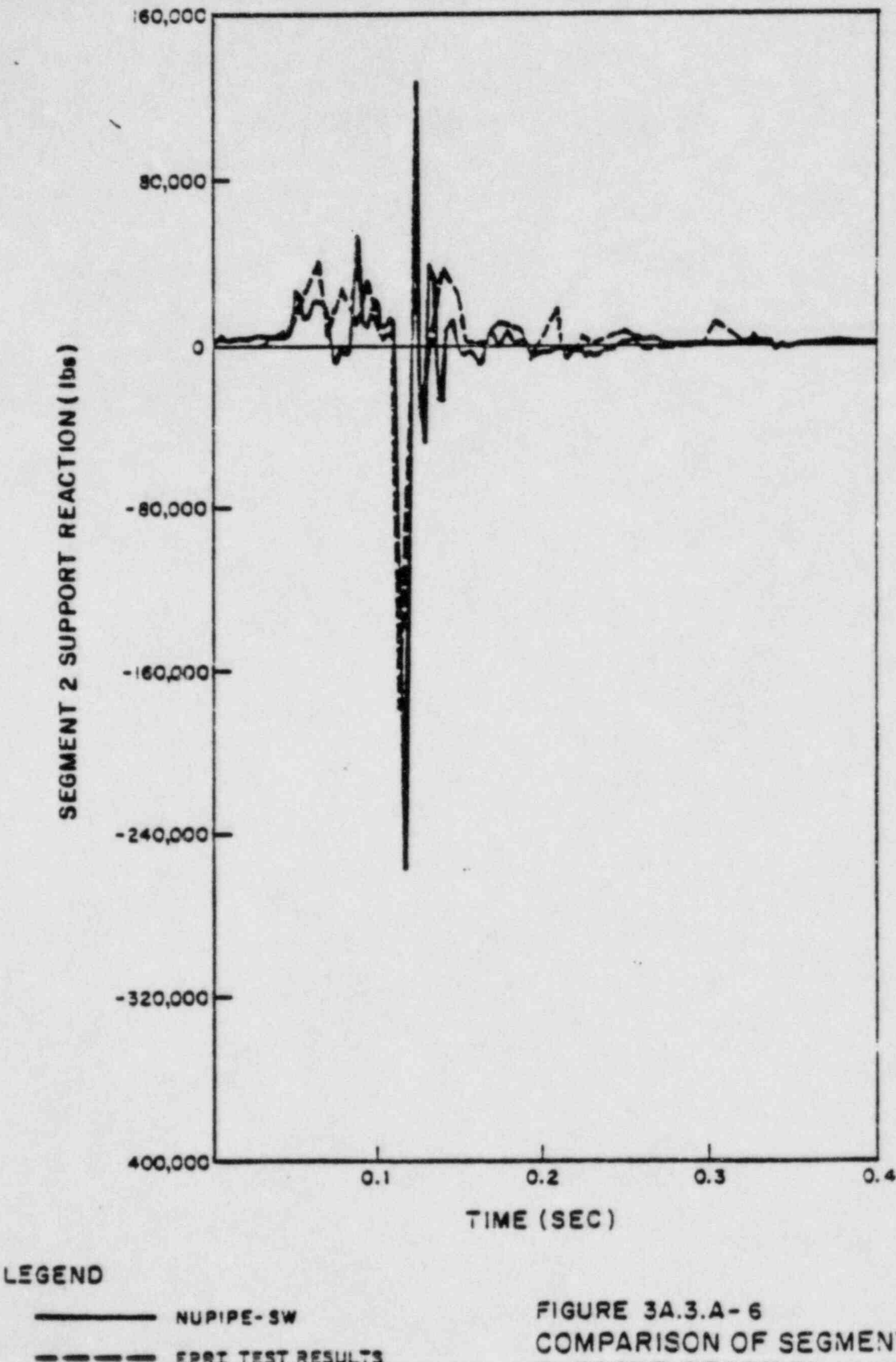


FIGURE 3A.3.A-6
COMPARISON OF SEGMENT 2
SUPPORT REACTION

ATTACHMENT 3

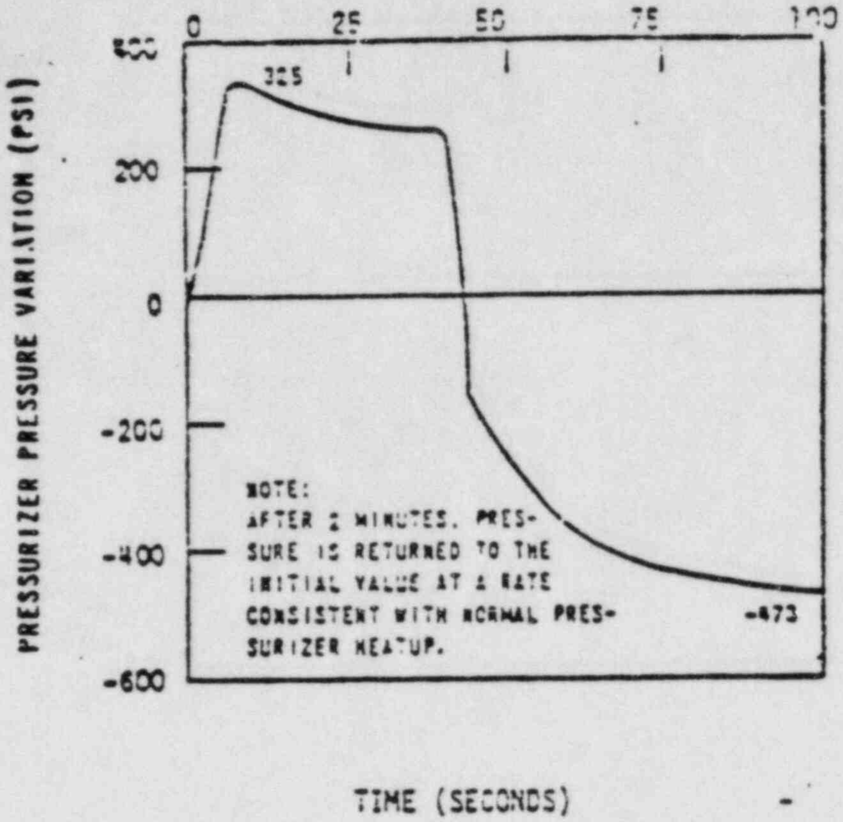


Figure 8 - Loss of Load - Pressurizer Pressure Variation
(30 cycles)

Extracted from Westinghouse Equipment Specification G-678838, Rev. 2, 10/19/77, "Pressurizer Safety Valves, ASME Boiler and Pressure Vessel Code, Section III, Class 1."

ATTACHMENT C

VENDOR	MODEL	RATED FLOW LBS/HR	MAXIMUM CALCULATED BENDING MOMENT (IN.-LBS)	EPRI APPLIED BENDING MOMENT (IN.-LBS)
DRESSER SAFETY VALVE	31739A	298,000	86,207[1]	242,000[2]
MASONEILAN RELIEF VALVE	38-20771	230,400	24,537[1]	35,600[3]

NOTES:

1. a. SWEC Calculation No. 14248.02-NP(B)-003-XC Rev. 0 dated December 22, 1983, Vepco North Anna Unit 1 Stress Analysis for Pressurizer Safety and Relief System Problem 700.

   b. SWEC Piping System Stress Analysis Report No. 12050-SSR-4 Rev. 0 dated December 21, 1978, Vepco North Anna Unit 2 Pressurizer Safety and Relief System

2. EPRI/C-2 Pwr. Safety Valve Test Report Vol. 3 of 10, Test Results for Dresser Safety Valve Model 31739A EPRI Research Project V102-2 Interim Report, July 1982.

3. EPRI/W,le Power-Operated Relief Valve Phase III Test Report Volume 6, Summary of Phase III Testing of the Masoneilan Relief Valve NP-2670-LD, Volume 6 Research Project V102-11 Interim Report, October 1982

ELECTRIC POWER RESEARCH INSTITUTE

EPRI

April 5, 1982.

TO: UTILITY TECHNICAL AND LICENSING CONTACTS, PWR NSSS VENDOR PRIMARY CONTACTS

SUBJECT: "GUIDE FOR APPLICATION OF VALVE TEST PROGRAM RESULTS TO PLANT SPECIFIC EVALUATIONS" - REVISION 1

At the request of the participating Utilities, EPRI and the Utility Technical Advisory Group (TAG) have compiled a guideline report describing a suggested procedure for Utilities to follow in preparing plant-specific submittals in response to NUREG 0737 ("Clarification of TMI-1 Action Plan Requirements") Section II.D.1.A Requirements. Attached to this letter is a copy of the subject report. A draft copy of this report was transmitted for your review on February 23, 1982. All comments have been incorporated into the attached.

If you have any questions regarding the attached, please contact me.

Sincerely,

Warren J. Bilanin

Warren J. Bilanin
Program Manager
Safety and Analysis Department

WJB/11
Attach.

Headquarters 3412 Hillview Avenue, Post Office Box 10412, Palo Alto, CA 94303 (415) 855-2000

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

INTERIM REPORT, MARCH 1982
(RESEARCH PROJECT V102)

Prepared by:

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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.

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

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

- Section V -- References

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

- Section VI - Appendices

  A. Procedure for Calculation of Valve Back Pressure

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

  B. Procedure for Calculation of Inlet Piping Pressure Effects

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

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

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

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

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

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

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

II. PROCEDURE TO BE FOLLOWED IN PLANT-SPECIFIC EVALUATIONS

A. Flow Charts for the Evaluations

1. Evaluation of Valve Performance

- Safety Valves

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

- EPRI valve program reports as listed in Section V of this guide.

- List of pertinent plant parameters as identified in Table III-1.

The evaluations to be performed consist of the following:

- An evaluation of test results by the valve manufacturer to identify any potential problem areas regarding valve performance.

- An evaluation by the NSSS vendor to identify any potential problem areas regarding overpressure protection system performance.

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

The output from the evaluations consists of:

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

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

- Relief Valves

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

2. Evaluation of Piping/Support Adequacy

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

   - Verified computer codes for determination of hydraulic loads and EPRI valve program reports as listed in Section V of this guide.

   - List of pertinent plant parameters as identified in Table III-1.

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

   - An evaluation of the piping stresses and support loads using the EPRI-provided codes or other method which has been verified by comparison of predictions with EPRI test data provided in Reference 7.

   - A comparison of calculated piping stresses and support loads with allowables and identification of any potential problem areas.

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

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

B. Workscopes for the Evaluations

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

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

TABLE II-1

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

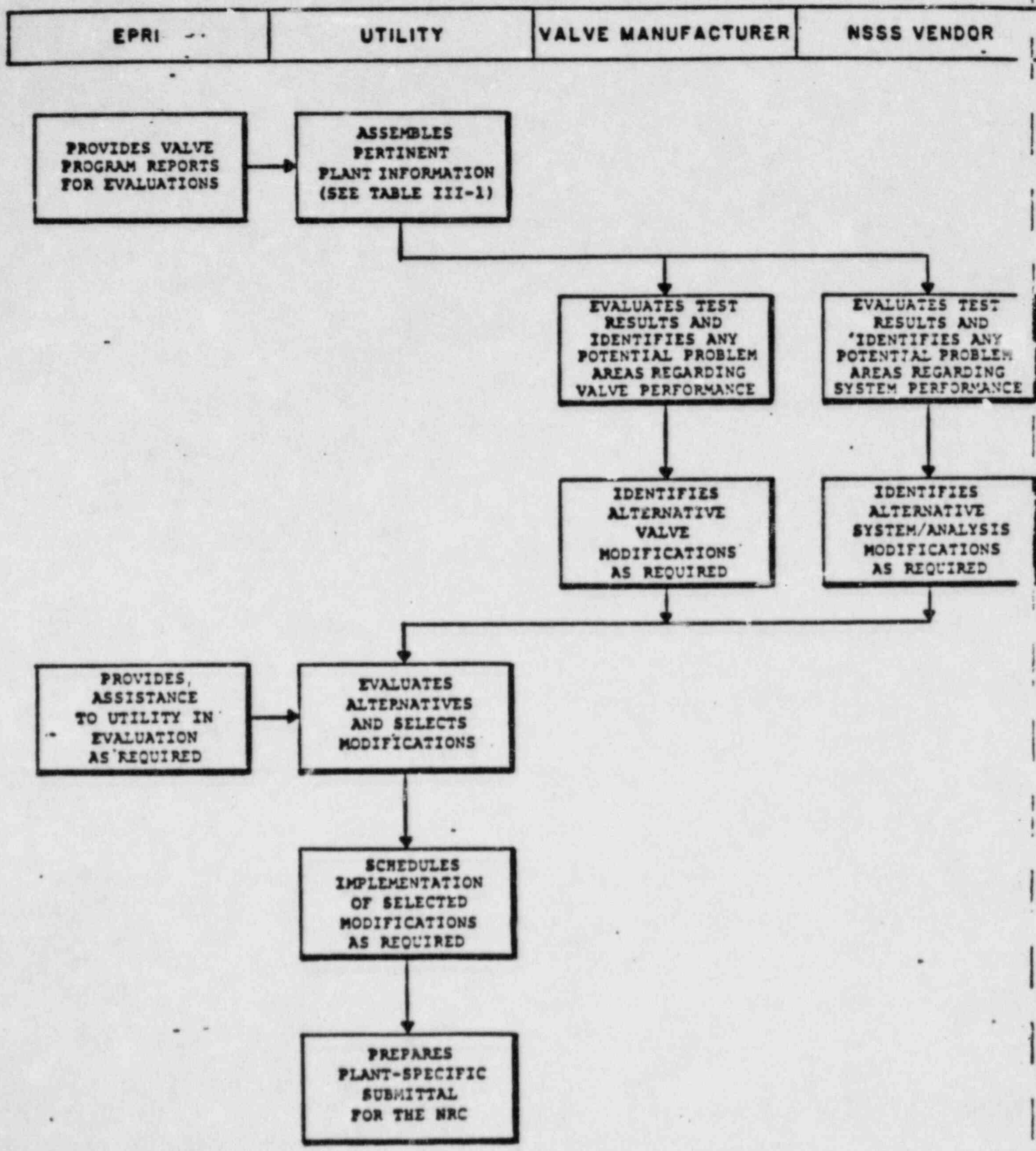


TABLE II-2

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

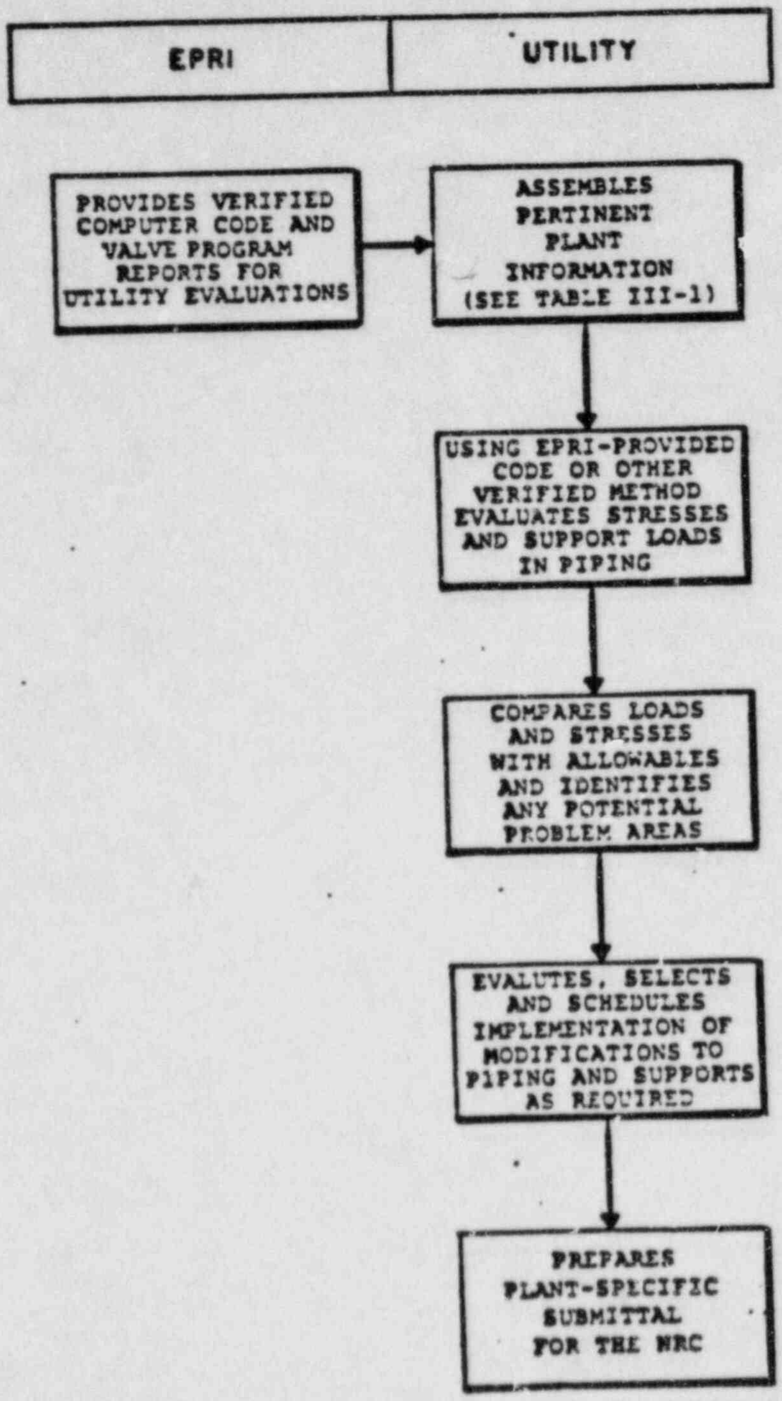


TABLE II-3

WORKSCOPE FOR UTILITY EVALUATION OF
SAFETY AND RELIEF VALVE PERFORMANCE

The utility will perform the following:

1. Identify pertinent plant information listed in Table III-1, including:

   - Valve parameters

   - Inlet piping parameters

   - Discharge piping parameters

   - Valve actuation transient parameters

2. Evaluate alternative modifications identified by valve manufacturer and/or NSSS vendor and select modifications for implementation.

3. Schedule implementation of selected modifications to valves.

4. Prepare plant-specific submittal for the NRC.

TABLE II-4

WORKSCOPE FOR UTILITY EVALUATIONS OF PIPING/SUPPORT ADEQUACY

The utility will perform the following:

1. Identify pertinent plant information listed in Table III-1, including:

   - Valve parameters
   - Inlet piping parameters
   - Discharge piping parameters
   - Valve actuation transient parameters

2. Using EPRI-provided code or other verified (by comparison with valve test results) method, evaluate stresses and support loads in inlet and discharge piping.

3. Compare loads and stresses with allowable values and identify any potential problem areas.

4. Evaluate, select and schedule implementation of modifications to piping and supports as required.

5. Prepare plant-specific submittal for the NRC.

TABLE II-5

WORKSCOPE FOR VALVE MANUFACTURER EVALUATION OF SAFETY VALVE PERFORMANCE

A. Bases for Evaluation

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

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

B. Scope of Evaluation

The valve manufacturer will perform the following:

1. Define performance for as-installed valve ring settings based on:

   - EPRI test data
   - Valve manufacturer's test data
   - Valve manufacturer's supporting analysis

   The evaluation should:

   - Determine which fluid conditions result in stable or unstable valve performance.
   - Establish valve performance characteristics (e.g., blowdown, lift, flow opening time, etc.).

2. Define performance for optimal valve ring settings in accordance with the steps identified in 1 above.

3. Recommend valve modifications to provide improved performance, if needed (e.g., to provide reduced blowdown, stable water performance, etc.).

4. Document performance recommendations and bases for recommendations to the utilities.

TABLE II-6

WORKSCOPE FOR VALVE MANUFACTURER EVALUATIONS OF RELIEF VALVE PERFORMANCE

A. Bases for Evaluation

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

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

B. Scope of Evaluation

The valve manufacturer will perform the following:

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

TABLE II-7

WORKSCOPE FOR NSSS VENDOR EVALUATION OF SAFETY AND RELIEF VALVE PERFORMANCE

A. Bases for Evaluation

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

1. Applicable EPRI test program outputs.

2. Plant information listed in Table III-1.

3. Valve performance characteristics (e.g., blowdown, lift, flow, opening time, etc.), as established by the valve manufacturer.

B. Scope of Evaluation

The NSSS vendor will perform the following:

1. Evaluate test results and document system acceptability or identify any potential problem areas regarding NSSS overpressure protection system performance.

2. If potential problems are identified:

   - Identify alternative modifications to NSSS overpressure protection system and/or overpressure transient analysis parameters to resolve unacceptable performance.

   - Concur with system/analysis modifications selected by utility for implementation.

   - Prepare report which justifies acceptability of system/analysis modifications selected for implementation.

TABLE II-8

WORKSCOPE FOR EPRI EVALUATIONS

A. Valve Performance

1. Provide valve program reports for utility evaluations.

2. Provide on-going assistance to utilities in the understanding and use of program outputs as required.

B. Piping/Support Adequacy

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

III. EVALUATION OF TEST RESULTS FOR PLANT-SPECIFIC CONDITIONS

A. Identification of Pertinent Plant Parameters

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

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

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

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

B. Procedures for Evaluation of Test Results

1. Safety Valve Performance and Associated Piping/Support Adequacy

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

- Step 1

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

- Step 2

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

- Step 3

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

- <u>Step 4</u>

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

- <u>Step 5</u>

  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.

- <u>Step 6</u>

  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).

- <u>Step 7</u>

  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 tes 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 th air and/or electrical supply and for pilot-operated valves the pilot vent discharge tubing for that installed in plants compared to that tested.

- <u>Step 3</u>

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

- <u>Step 4</u>

  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).

- <u>Step 5</u>

  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).

- <u>Step 6</u>

  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:

- <u>Safety Valves</u>

  1. <u>Performance with Steam Flow</u>

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

  2. <u>Performance with Subcooled Water Flow</u>

     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)

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

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.
	(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.)
	Utilize alternative valve which provides stable performance with smaller blowdown.
	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.
	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.

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

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

TABLE III-6

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

TESTED VALVES	INLET FLUID CONDITIONS					
	STEAM	LOOP SEAL	TRANSITION	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
• 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. Purpose

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

B. Discussion

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

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

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

APPENDIX B

PROCEDURE FOR CALCULATION OF INLET PIPING PRESSURE EFFECTS

A. Purpose

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

B. Discussion

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

1. Inlet Piping Flow Pressure Drop (ΔP_F)

The flow pressure drop is given by,

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

where,

k = expansion or contraction loss coefficient (dimensionless)

f = friction factor (see Reference 1) (dimensionless

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

$\dot{M}$ = maximum valve flow rate for steam (as established by the safety valve manufacturer) (lb/sec)

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

ρ = steam density at nominal valve set pressure (lb/ft^3)

A = inlet piping flow area (ft^2)

2. Acoustic Wave Amplitude (ΔP_{AW})

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

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

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

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

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

where,

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

L = inlet piping length (ft)

T_{op} = valve opening time for steam inlet conditions as established from the EPRI testing effort is 10msec for the Crosby safety valves and 15msec for the Dresser safety valves.

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

3. Plant-Specific Pressure Drop

The plant-specific pressure drop associated with valve opening is equal to the sum of the friction pressure drop (ΔP_F) and the acoustic wave amplitude (ΔP_{AW}) as determined above. For certain test valves, valve reopening and/or chatter was observed on valve closure. For similar valve/installations, the pressure rise associated with valve closure may have to be evaluated.

C. References

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

2. Waterhammer Analysis, John Parmakian, Dover Publications, Inc., 1963.

D. <u>Sample Problem</u>

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

1. <u>Flow Pressure Drop</u>

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

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

where,

k = 0.5(1)* (sudden contraction at pressurizer nozzle)

f = .016(1)

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

ρ = 7.65 lb/ft^3 (2) (saturated steam at 2500 psia)

A = 0.147 ft^2

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

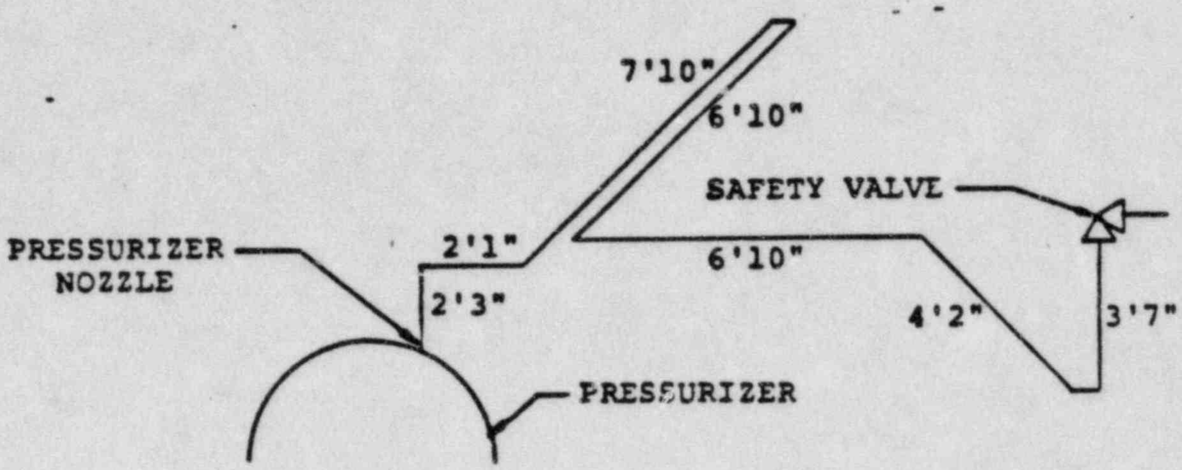
The flow pressure drop is,

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

ΔP_F = 36 psi

---

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



- TOTAL PIPE LENGTH = 33'7"
- PIPE DIAMETER = 6" SCH. 160 (5.189" INSIDE DIAM.)
- FITTINGS
  - 6, 90° ELBOWS
  - 2, 45° ELBOWS

-CROSBY 4M16 SAFETY VALVE
  - 345,000 lb/hr RATED CAPACITY
  - .010 SEC OPENING TIME

SAFETY VALVE INLET PIPING CONFIGURATION

FIGURE B-1

2. Acoustic Wave Amplitude

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

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

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

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

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

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

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

3. Plant-Specific Pressure Drop

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

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

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

4. References

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

(2) ASME Steam Tables, 1967.

(3) "A Pressure Pulse Model for Two-Phase Critical Flow and Sonic Velocity," ASME 68-WA/HT-8.

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

Following are Tables B.1 through B.6 entitled "Safety Valve Description and Inlet Piping Configuration". These tables provide a description of the tested safety valves and the inlet piping configurations on which the valves were mounted. The information contained in these tables are the same as the information contained in Tables 3.1.1.a through 3.6.1.a of Reference 1 (see Section V) with the addition of the calculated transient pressure drop for each test inlet pipe configuration.

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

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

EPRI/CE SAFETY VALVE TEST PROGRAM

TABLE B.1

SAFETY VALVE DESCRIPTION AND INLET PIPING CONFIGURATION

DRESSER 31739A SAFETY VALVE

__Valve Description__

Manufacturer	Dresser Industries
Type	Spring Loaded Safety Valve
Model No.	31739 A
Serial No.	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

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

__Inlet Piping Configuration__ "D"

	Length, in.	I.D., in.
Nozzle	17	6.813
Venturi	38	6.813
Pipe	11	6.813
Reducer	6	6.813/3.152
Loop Seal		
Straight	60	3.152
Bends	4-90°	6 in. radius
Reducer	4	3.152/2.125
Inlet Flange	6	2.125

Transient Pressure Drop (1) 454 psi

__Inlet Piping Configuration__ "C"

	Length, in.	I.D., in.
Nozzle	17	6.813
Venturi	38	6.813
Pipe	11	6.813
Reducer	10	6.813/2.125
Pipe	Not applicable	
Inlet Flange	6	2.125

Transient Pressure Drop (1) 54 psi

EPRI/CE SAFETY VALVE TEST PROGRAM

TABLE B.2

SAFETY VALVE DESCRIPTION AND INLET PIPING CONFIGURATION

DRESSER 31709NA

Valve Description

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

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

Design Set Point Pressure 2500 psig

Design Blowdown 5 percent

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

Internals Type: not applicable

Ring Setting Reference Position:
The ring setting positions refer to the number of notches relative to the following surfaces;

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

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

Inlet Piping Configuration "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

Transient Pressure Drop (1) NOT AVAILABLE

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

Transient Pressure Drop (1) 88 psi

EPRI/CE SAFETY VALVE TEST PROGRAM

TABLE B.3

SAFETY VALVE DESCRIPTION AND INLET PIPING CONFIGURATION

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

Valve Description

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

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

Design Set Point Pressure 2485 psig

Design Blowdown 5 percent

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

Internals Type: Steam

Ring Setting Reference Position:

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

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

Inlet Piping Configuration "F"

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

Transient Pressure Drop (1) 321 psi

Inlet Piping Configuration "E"

	Length, in.	I.D., in.
Nozzle	17	6.813
Venturi	38	6.813
Pipe	6	6.813
Reducer	10	6.813/2.624
Pipe	4	2.624
Inlet Flange	7	2.624

Transient Pressure Drop (1) 56 psi

EPRI/CE SAFETY VALVE TEST PROGRAM

TABLE B.4

SAFETY VALVE DESCRIPTION AND INLET PIPING CONFIGURATION

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

Valve Description

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

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

Design Set Point Pressure 2485 psig

Design Blowdown 5 percent

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

Internals Type: Loop Seal

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

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

Inlet Piping Configuration "F"

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

Transient Pressure Drop (1) 321 psi

Inlet Piping Configuration "E"

	Length, in.	I.D., in.
Nozzle	17	6.813
Venturi	38	6.813
Pipe	6	6.813
Reducer	10	6.813/2.624
Pipe	4	2.624
Inlet Flange	7	2.624

Transient Pressure Drop (1) 56 psi

EPRI/CE SAFETY VALVE TEST PROGRAM

TABLE B.5

SAFETY VALVE DESCRIPTION AND INLET PIPING CONFIGURATION

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

Valve Description

Manufacturer	Crosby Valve and Gage 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°	9 in. radius
Reducer	Not Applicable	
Inlet Flange	10	4.897

Transient Pressure Drop (1) 251 psi

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

EPRI/CE SAFETY VALVE TEST PROGRAM

TABLE B.6

SAFETY VALVE DESCRIPTION AND INLET PIPING CONFIGURATION

FOR THE CROSBY HB-BP-86 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

Transient Pressure Drop (1) 270 psi

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

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 (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:

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

- Test 2 -- The test is directly applicable because the valve ring settings, plant backpressure, inlet piping pressure and fluid condition requirements specified in Table D-1 are satisfied.

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

- Test 4 -- This test is not directly applicable because the plant inlet piping pressure drop is greater than the test inlet piping pressure drop.

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

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

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

TABLE D-1

PROCEDURE FOR ASSESSMENT OF APPLICABILITY OF SPECIFIC EPRI TESTS

- STEP A -- VALVE RING SETTINGS

- For Valves Tested in the EPRI Program:

  1. Are the ring settings for the plant valve the same as for the tested valve?

  2. If the answer to the above question is yes, proceed to Step B.

  3. If the answer to the above question is no, the test is not directly applicable to the plant evaluation.

- For Valves not Tested in the EPRI Program:

  1. Is the plant valve represented by a test valve per Reference 2 (see Section V)?

  2. Do the ring settings for the plant valve correspond to those specified by the valve manufacturer to obtain similar performance as observed for the test valve?

  3. If the answers to Questions 1 and 2 are both yes, proceed to Step B.

  4. If the answer to either Question 1 or 2 is no, the test is not directly applicable to the plant evaluation.

TABLE D-1 Cont'd

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

1. Is the plant backpressure less than the backpressure in the test? (This comparison should be made for steam discharge condition as discussed in Appendix A.)

2. If the answer to the above question is yes, proceed to Step C.

3. If the answer to the above question is no, the test is not directly applicable to the plant evaluation. (However, if unacceptable valve performance was observed in the test, it is highly probable that unacceptable valve performance would also result at the plant backpressure condition.)

TABLE D-1 (Cont'd)

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

1. Is the plant inlet piping pressure drop due to valve opening less than the corresponding value for the test? (This comparison should be made for the steam discharge condition as discussed in Appendix B.)

2. If the answer to the above question is yes, proceed to Step D.

3. If the answer to the above question is no, the test is not directly applicable to the plant evaluation. (However, if unacceptable valve perforamnce 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.)

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

TABLE D-1 (Cont'd)

STEP D -- INLET FLUID CONDITION

1. Is the inlet fluid condition for the plant (see list in Table II-1 of this guide) the same as the inlet fluid condition for the test?

2. If the answer to the above question is yes, the applicability assessment is complete and the test is determined to be applicable to the plant evaluation.

3. If the answer to the above question is no, the test is not directly applicable to the plant evaluation.

TABLE D-2

SAMPLE TEST APPLICABILITY ASSESSMENTS ***

	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)	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.

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

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	$N + OBE + SOT_U$	B
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-strea[m] 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 applicabl[e] system operating transient defined in Table 3 should be [illegible]

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.