SUMMARY REPORT

ON THE

OPERABILITY OF THE

SHUTDOWN COOLING SYSTEM

RELIEF VALVES

FOR

WATERFORD UNIT 3

December 1984

TABLE OF CONTENTS

1.0 PURPOSE

The purpose of this report is to document the bases for operability of the Crosby 6Q8 JB-55-TD-W relief valves used in the Shutdown Cooling System (SCS) at Waterford Unit 3. This report was prepared in response to an NRC request for additional information concerning relief valve operability contained in Reference (1).

2.0 SCOPE

This report addresses the operability of the Crosby 6Q8 JB-55-TD-W liquid relief valves used in the SCS at Waterford Unit 3. Each of these valves has a six-inch inlet, an eight-inch outlet and a "Q" orifice designation (11.045 square inches). The set pressure for the relief valves is 415 psig; design temperature is 400°F. There is one relief valve installed in each of the two SCS trains.

The term "operability" is used in this report as a general expression of valve performance to indicate the ability of the valve to open at the required pressure, relieve at the minimum rated capacity and reclose following inlet pressure decay.

3.0 BASIC OPERABILITY DATA

The operability discussion for the Waterford SCS relief valves contained in this report is based on two key pieces of information:

1. Water test data for a Crosby 6R8 JB-25-3-TD relief valve with a set pressure of 75 psig. (Reference 2). This valve has a six-inch inlet, an eight-inch outlet and an "R" orifice designation (16.0 square inches).
2. Steam test data for Crosby JB series relief valves. Tests were conducted on a 4P6 JB-56-TD relief valve and a 6R10 JB-56-TD relief valve (References 4 and 5, respectively) with steam at pressures of approximately 500 psig and saturation temperatures of 467°F. The first valve has a four-inch inlet, a six-inch

outlet and a "P" orifice designation (6.379 square inches). The second valve has a six-inch inlet, a ten-inch outlet and an "R" orifice designation (16.0 square inches).

4.0 DISCUSSION OF OPERABILITY

The operability of the Waterford SCS relief valves is demonstrated by applying the basic operability data identified in Section 3.0 to the Waterford valves. These data are implemented to supplement and support three principal arguments on which the operability of the Crosby 6Q8 JB-55-TD-W relief valve is based.

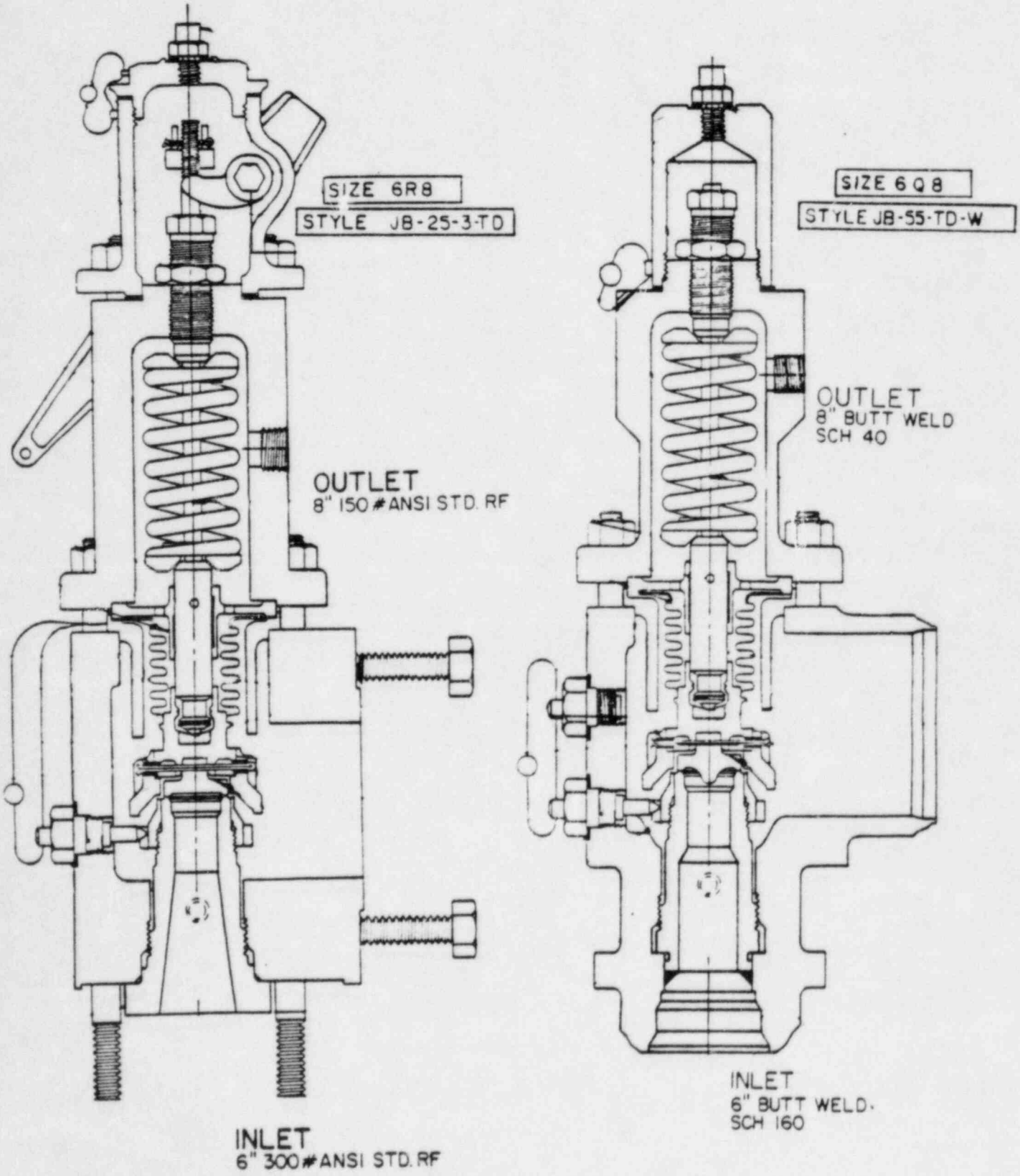
1. Test data for the Crosby 6R8 JB-25-3-TD relief valve are applicable to the Crosby 6Q8 JB-55-TD-W relief valve.
2. Water test data from a 75 psig set pressure test conducted on room temperature water are applicable to 415 psig set pressure operation at the same temperature.
3. Steam tests for Crosby JB series relief valves provide a basis for operability of the Crosby 6Q8 JB-55-TD-W relief valve for higher temperature service (up to 400°F).

The following three subsections contain discussions of the three bases for operability identified above. Each of the three bases is considered independently as a component of the overall discussion of operability.

4.1 COMPARISON OF 6Q8 AND 6R8 VALVES

The comparison of the 6Q8 JB-55-TD-W and the 6R8 JB-25-3-TD is presented to show that the 6R8 test results are applicable to the Waterford 6Q8 relief valve. The two relief valves which are shown in Figure 4-1 are compared on the basis of 1) physical geometry, 2) materials and 3) functional characteristics.

FIGURE 4-1 CROSBY 6Q8 JB-55-TD-W AND 6R8 JB-25-3-TD RELIEF VALVES



4.1.1 PHYSICAL GEOMETRY

The 6Q8 and 6R8 relief valves are both members of a family of similar JB series valves manufactured by Crosby. Although the Waterford 6Q8 valve is smaller than the 6R8 valve they are very similar in that:

1) the critical valve control dimensions are proportional
2) the nozzle geometry is the same
3) one adjustable control ring is used for adjustments of valve performance characteristics; and
4) the clearances between the moving parts are comparable and are appropriate for the service conditions.

Other than size, the only difference between the physical geometry of the valves is in the disc insert design. The 6Q8 valve has a conical disc insert shape, while the 6R8 valve has a flat disc insert. Both valves have the same inlet and outlet sizes. The nozzle for Waterford's 6Q8 valve is only one size smaller than the nozzle for the 6R8 test valve. This difference is not considered significant. The critical valve control dimensions are proportional.

4.1.2 MATERIALS

The materials in both the 6Q8 and 6R8 relief valves were selected to avoid galling and were tested by Crosby for water service. The guiding components are of the same material, and the seating surfaces are of similar stainless steel materials (Types 304 and 316).

4.1.3 FUNCTIONAL CHARACTERISTICS

The same design philosophy was used in both the 6Q8 and 6R8 valves. The adjustment ring settings have the same basis. Similar functional behavior is expected for the two valves.

4.1.4 SUMMARY OF APPLICABILITY OF 6R8 TO 6Q8

The following points summarize the applicability of the satisfactory 75 psig test of the 6R8 to the 6Q8 relief valve:

- o The critical valve control dimensions are proportional
- o The only geometrical difference between the 6R8 valve and the 6Q8 valve is in the shape of the disc insert and is not considered significant. Only minor material differences exist between the test valve and the plant valve.
- o The same design philosophy was used for each valve
- o The ring settings have the same basis

Therefore, the test of the 6R8 valve is believed applicable to the 6Q8 valve used at Waterford Unit 3.

4.2 APPLICABILITY OF PRORATED TEST RESULTS TO FULL PRESSURE OPERABILITY

The following discussion is intended to show that prorated (low pressure spring) tests in general are applicable to relief valve operation at full pressure conditions, given the same fluid state (subcooled liquid) and temperature conditions. That way the water test performance of a relief valve tested at 75 psig can be applied to performance at 415 psig at the same temperature. The comparison of prorated and full pressure operability is made on the basis of 1) mechanical valve operation and 2) valve/fluid interaction.

4.2.1 MECHANICAL VALVE OPERATION

Mechanical valve operation is used here to mean the relative movement of the relief valve internals. Identical mechanical valve operation is expected for 75 psig and 415 psig. Clearances in the valve internals are not a function of pressure. The same ring settings would be used at prorated and full pressures.

4.2.2 VALVE/FLUID INTERACTION

The manner in which the relief valve reacts to fluid conditions at the valve inlet is expected to be the same. Thus, the relief valve operating characteristics of valve stem position vs. inlet pressure, and valve opening response time are expected to be the same at 75 psig as those at 415 psig. The percent blowdown should be comparable for the same ring settings. A very significant point to be made is that the margin to stability will increase with increasing set pressure for constant percentage blowdown. Figure 4-2 depicts this phenomenon for the general case of a liquid relief valve set at 75 psig and 415 psig. The figure is a plot of valve inlet pressure drop calculated to occur at valve opening for a given valve operating characteristic and inlet piping configuration. As indicated in the figure there will be a drop in inlet pressure when a relief valve opens due to the acceleration of the fluid. When the pressure drop is expressed as a percentage of the set pressure, it is seen that the percentage drop in inlet pressure decreases as the set pressure increases. As for stability, the smaller the percentage pressure drop, the more margin there is between the minimum valve inlet pressure and reseat (or blowdown) pressure. So long as the inlet pressure does not fall below the reseat pressure the relief valve will remain open and will operate in a stable manner. Therefore, prorated tests are a conservative means for assessing valve stability.

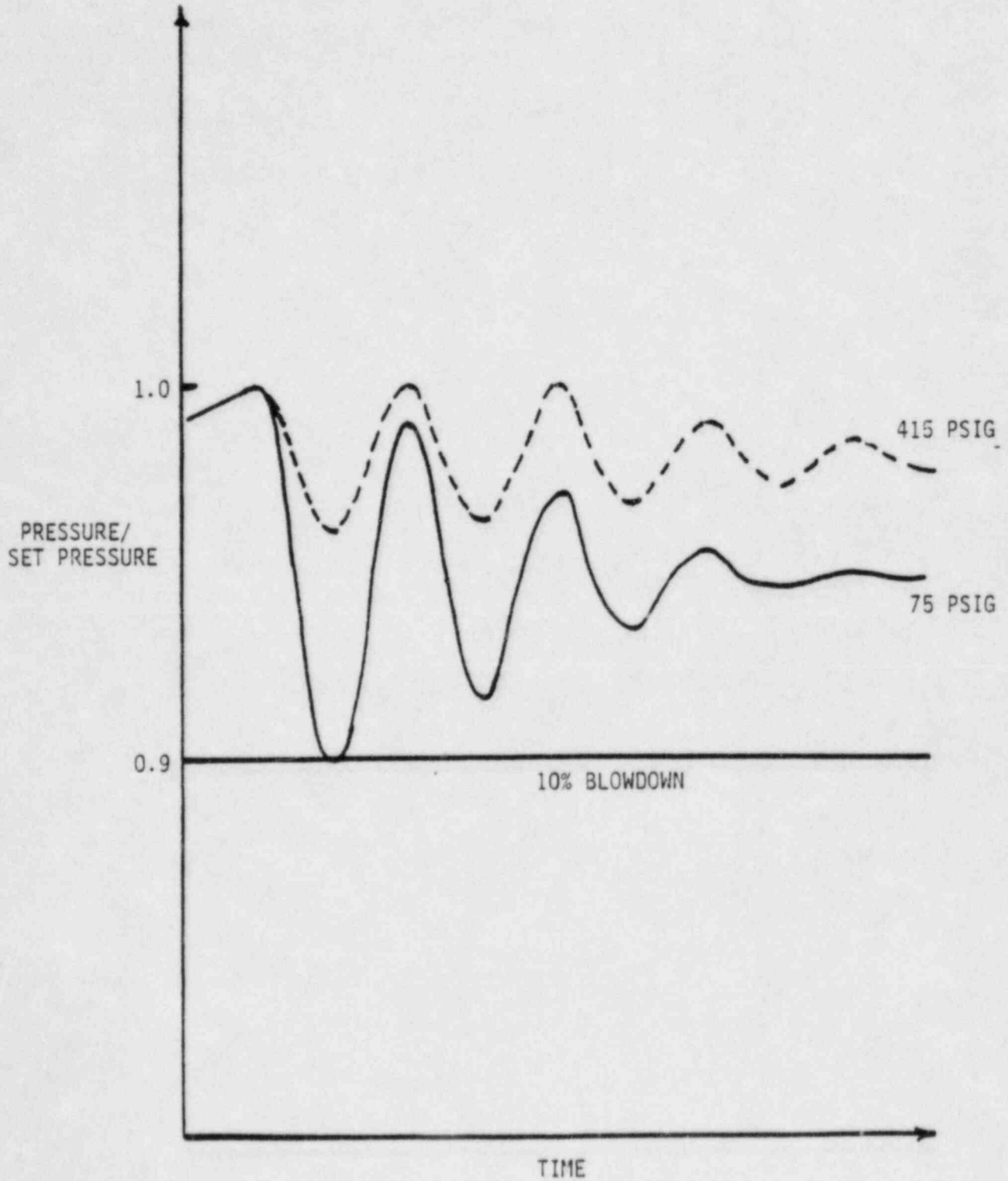
4.2.3 SUMMARY OF APPLICABILITY OF PRORATED TEST RESULTS TO FULL PRESSURE OPERABILITY

The following points summarize the applicability of prorated test results to full pressure operability:

- Low pressure (prorated spring) test results are considered representative of operation at full pressure.

FIGURE 4-2

RELATIVE RELIEF VALVE STABILITY VS. SET PRESSURE



- o A relief valve is more likely to chatter at low pressure if the percentage blowdown is the same. Therefore, prorated tests are a conservative means for assessing relief valve stability.

4.3 JUSTIFICATION OF OPERABILITY AT DESIGN TEMPERATURE

In subsection 4.1 it was shown that the satisfactory test of a 6R8 JB-25-3-TD relief valve is applicable to operation of the 6Q8 JB-55-TD-W relief valve at low pressure with room temperature water. In other words, both valves are expected to exhibit similar performance with the same fluid conditions. Then in subsection 4.2 the operability argument was extended to full pressure but still with cold water conditions. Subsection 4.3 provides the arguments necessary to complete the overall operability discussion for the Waterford 6Q8 valve by justifying valve operability over the full range of operating temperatures. These arguments are based on steam tests for JB series relief valves with steam temperatures in excess of 400°F as well as on experience gained from the EPRI/C-E PWR Safety Valve Test Program. The considerations of temperature effects on relief valve operability are based on 1) mechanical valve operation and 2) valve/fluid interaction in the same manner used in subsection 4.2.

4.3.1 MECHANICAL VALVE OPERATION

Steam tests were conducted by Crosby on JB series relief valves to demonstrate seismic operability. Test data are available for both a 4P6 and a 6R10 JB-56-TD relief valve (References 4 and 5, respectively). These valves bracket the size of the Waterford 6Q8 valve, the 4P6 being one size smaller and the 6R10 being one size larger than the 6Q8 valve. The valves were tested with saturated steam at pressures of approximately 500 psig with temperatures well in excess of the 400°F design temperature for the Waterford valve. No evidence of poor valve operation, instability or inconsistency in valve performance was observed during the tests. These tests demonstrated proper valve operation of the JB series relief valves for temperatures in excess of 400°F.

4.3.2 VALVE/FLUID INTERACTION

The EPRI safety valve tests (Reference 3) demonstrated that spring-loaded safety valves were more prone to chatter as the degree of subcooling increased. Although the safety valves tested in the EPRI program were designed for steam service, both safety valves and relief valves are fundamentally spring-mass systems for which the principle of valve/fluid interaction is the same. Therefore, prorated tests with cold water are conservative due to the large amount of subcooling and the increased tendency to chatter as fluid temperature decreases.

4.3.3 SUMMARY OF OPERABILITY AT DESIGN TEMPERATURE

The following points summarize the operability discussion for the 6Q8 JB-55-TD-W relief valve at design temperature:

- o Acceptable mechanical valve operation at design temperature is demonstrated by the Crosby JB series steam tests.
- o Valve/fluid interactions are conservatively determined with prorated spring tests at low temperatures.

Thus the valve operability over the range of operating temperatures is bounded by the prorated test of the 6R8 JB-25-3-TD valve at room temperature conditions and the JB series steam tests at design temperature.

5.0 SUMMARY

The following points are a summary of the discussions contained in this report regarding the operability of the Waterford Unit 3 6Q8 JB-55-TD-W relief valve:

- o A satisfactory low pressure test of a 6R8 JB-25-3-TD relief valve is believed applicable to the 6Q8 JB-55-TD-W relief valve.

- o Low pressure test results are considered representative of operation at full pressure.
- o A liquid relief valve is more likely to chatter at low pessure if the percent blowdown is the same.
- o Acceptable mechanical valve operation at design temperature is demonstrated by the Crosby JB series steam tests.
- o Valve/fluid interactions over the range of operating temperatures are bounded by the 6R8 JB-25-3-TD relief valve test and the Crosby JB series steam tests.

In conclusion, based on the relevant test data and engineering evaluations, acceptable operability is expected for the Crosby 6Q8 JB-55-TD-W relief valve.

6.0 REFERENCES

1. NRC letter, G.W. Knighton (NRC) to R. Leddick (LP&L) dated April 18, 1984.

2. Crosby Valve and Gage Company Test Report No. 4090, "Seismic Qualification Test of a 6R8 JB-25-3-TD Nozzle Type Relief Valve", November 28, 1983.

3. EPRI/C-E PWR Safety Valve Test Report, EPRI NP-2770-LD, Project V102-2 Interim Report, January 1983.

4. Crosby Valve and Gage Company Test Report No. 4099 - Revision No. 1, "Seismic Qualification Test of a 4P6 JB-56-TD Nozzle Type Relief Valve", January 27, 1984.

5. Crosby Valve and Gage Company Test Report No. 3827, "Report on Seismic Qualification Test of a Crosby 6R10 JO-55 Nozzle Type Relief Valve "(based on Crosby 6R10 JB-56-TD steam service valve), December 11, 1979