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TECHNICAL EVALUATION REPORT OF THE OVERPRESSURE
PROTECTION SYSTEM FOR BEAVER VALLEY POWER STATION,
UNIT NO. 1

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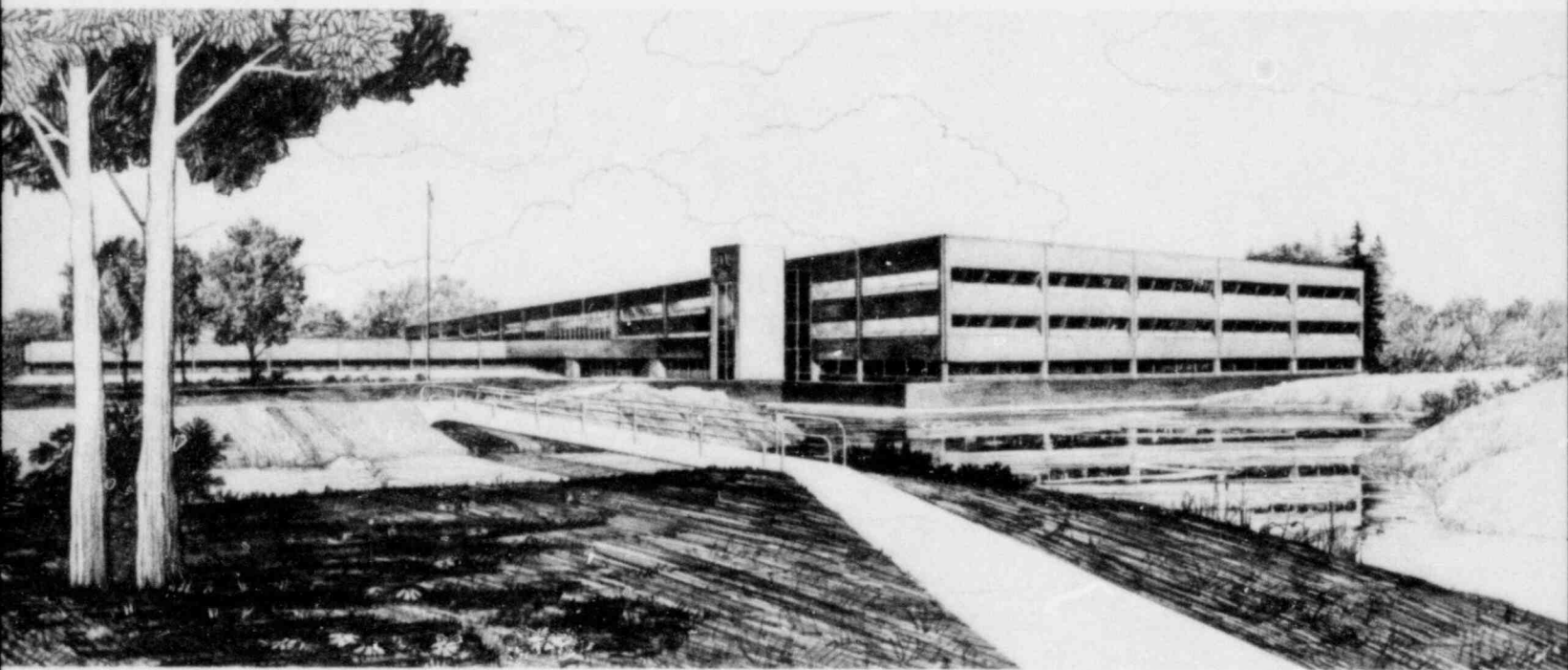
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TECHNICAL EVALUATION REPORT OF
THE OVERPRESSURE PROTECTION SYSTEM
FOR BEAVER VALLEY POWER STATION, UNIT NO. 1

March 1982

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ABSTRACT

This report documents the technical evaluation of the low temperature overpressure protection system of the Beaver Valley Nuclear Power Station, Unit 1. The criteria used to evaluate the acceptability of the system are those criteria contained in NUREG-0224 as appended by the Branch Technical Position (RSB 5-2).

FOREWORD

This report is supplied as part of the "Steam Generator Transients and Operating Reactors Evaluation for Reactor Systems Branch" being conducted for the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Division of Systems Integration, by EG&G Idaho, Inc., Reliability and Statistics Branch.

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CONTENTS

1.0	INTRODUCTION.....	1
2.0	DESIGN CRITERIA.....	1
3.0	SYSTEM DESCRIPTION AND EVALUATION.....	1
3.1	Air Supply.....	2
3.2	Electrical Controls.....	2
3.3	Testability.....	2
3.4	Single Failure Criteria.....	2
3.5	Seismic Design.....	3
3.6	Analysis Results.....	4
3.6.1	Mass Input Case.....	4
3.6.2	Heat Input Case.....	4
4.0	ADMINISTRATIVE CONTROLS.....	5
5.0	CONCLUSIONS.....	6
6.0	REFERENCES.....	7

TECHNICAL EVALUATION REPORT OF
THE OVERPRESSURE PROTECTION SYSTEM
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1.0 INTRODUCTION

Several instances of reactor vessel overpressurization have occurred in pressurized water reactors in which the technical specifications implementing Appendix G to 10 CFR Part 50 have been exceeded. The majority of cases have occurred during cold shutdown while the primary system was in a water-solid condition. By letter to the Duquesne Light Company (DLC), owner and operator of the Beaver Valley Power Station, dated August 11, 1976 (Ref. 1), the U.S. Nuclear Regulatory Commission (NRC) requested an evaluation of Beaver Valley Unit 1 to determine susceptibility to overpressurization events and an analysis of these possible events, and required DLC to propose interim and permanent modifications to the systems and procedures to reduce the likelihood and consequences of such events.

DLC participated as a member of a Westinghouse owner's group which provided a reference mitigating system and analyses to verify the adequacy of the system (Ref. 9). DLC modified the reference mitigating system and proposed their Reactor Vessel Overpressure Protection System (RVOPS) along with administrative procedure modifications and operator training (Ref. 6, 7, 10 and 12). The RVOPS is designed to mitigate the consequences of an overpressurization event and the additional operator training and the administrative procedure modifications are intended to reduce the probability of the occurrence of an overpressurization event.

This is a report of the evaluation of the compliance of the licensee's Overpressure Protection System with the design criteria established by the NRC.

2.0 DESIGN CRITERIA

The NRC formally addressed reactor vessel overpressurization in August 1976, and requested that the utilities provide a solution to the problem. The design criteria were subsequently identified through meetings and correspondence with utility representatives. NUREG-0224, "Reactor Vessel Pressure Transient Protection for Pressurized Water Reactors" with appended Branch Technical Position (RSB 5-2) formalizes the staff requirements for the overpressure mitigating system. This NUREG also includes a thorough discussion of the background of this problem and technical discussions pertaining to vessel stresses and other aspects of vessel overpressurization.

3.0 SYSTEM DESCRIPTION AND EVALUATION

The Beaver Valley RVOPS consists of two separate trains, each containing a power-operated relief valve (PORV), an isolation valve and associated circuitry. When in the low pressure mode the system provides a low pressure setpoint of 350 psig for both PORV trains. When the system is enabled, it will terminate all analyzed pressure transients below the Appendix G limit

by automatically opening the PORVs. A manual switch is used to enable and disable the low setpoint of each relief valve. An enabling alarm which monitors system pressure is provided to alert the control room operator to enable the overpressure mitigating system when system pressure drops to a predetermined point. In addition, an alarm is provided in the control room to indicate when an overpressure transient is occurring.

3.1 Air Supply

The power-operated relief valves (PORVs) are spring-loaded-closed, air-required-to-open valves, which are normally supplied by the containment instrument air system. To assure operability of the valves upon loss of containment instrument air, a backup nitrogen supply is provided. Nitrogen is supplied by the nitrogen manifold that provides nitrogen to the safety injection accumulators. The backup system is seismically designed and supported, and includes an accumulator for each PORV, with sufficient accumulated nitrogen to permit ten minutes of operation without any additional operator action. The accumulator is charged to 675 psig and at 600 psig a pressure switch will initiate an alarm in the control room.

3.2 Electrical Controls

The electrical, instrumentation, and control system aspects of the Beaver Valley Unit 1 low temperature overpressure protection system (RVOPS) have been reviewed and reported in a separate technical evaluation (Ref 15).

3.3 Testability

Testability is provided for the Beaver Valley RVOPS. DLC has stated that a channel functional test will be performed prior to enabling the system during plant cooldown and monthly thereafter when the system is required. The functional test will include actual valve stroking at the desired setpoint. Testing requirements are incorporated in the Technical Specifications.

3.4 Single Failure Criteria

The specified single failure criteria for the overpressure mitigating system is that it should be designed to protect the vessel given a single failure in addition to the failure that initiated the pressure transient. The Beaver Valley RVOPS meets this criteria for all cases reviewed except for the case where the initiating event is a loss of power from one 125V DC bus. This loss of power would result in isolation of the letdown line and one PORV failing to open upon request. Because the other PORV is powered from the other DC bus, it will remain functional. However, when a single failure is postulated in the remaining PORV, no low-temperature overpressure protection is afforded the plant.

Beaver Valley Unit 1 is susceptible to this scenario when the letdown path is the normal letdown via the Chemical and Volume Control System (CVCS). Letdown via the excess letdown heat exchanger and via the Residual

Heat Removal System (RHR) are not affected because of the use of motor-operated valves that fail in the "as is" position upon loss of control power.

DLC maintains a vapor space in the pressurizer during plant cooldown by establishing a nitrogen volume as the steam bubble is being collapsed. The nitrogen volume reduces the amount of time that the plant is in a water-solid condition, which provides a buffer against overpressurization of the reactor coolant system (RCS). This buffer allows the operator time to take corrective action to prevent exceeding the Appendix G limits. However, there are periods of time when no steam or nitrogen volume exist in the pressurizer and the plant is in a water-solid condition (i.e., during the fill and vent procedure). There could also be periods of time when the gas or vapor volume is of insufficient size to allow the required 10 minutes after the operator is alerted to a pressure transient before he must take action to preclude exceeding the Appendix G limits. During these periods there would be no protection for an overpressure transient at Beaver Valley Unit 1.

There is a safety valve in Beaver Valley's RHR system with sufficient capacity to mitigate this scenario, however, it is set to lift at 600 psig, which is above the Appendix G limits for low temperatures, and the RHR system is automatically isolated at a pressure of 630 psig. Therefore no credit can be taken for this system in mitigating overpressure transients.

We conclude that the Beaver Valley RVOPS meets the single failure criteria except for those times when an insufficient steam or nitrogen volume exists in the pressurizer to allow for the 10 minute delay between when the operator is alerted and when he must take action to mitigate a pressure transient. DLC is presently formulating a response to this issue.

3.5 Seismic Design

The specified seismic criteria is that the overpressure protection system should be designed to function during an Operating Basis Earthquake. The RVOPS installed at Beaver Valley Unit 1 is Seismic Category I with the exception of the PORV operators which have not been specifically qualified for operation through an OBE. The PORVs were purchased to a Westinghouse E Spec. which required the valve operators and valve assemblies to withstand seismic loadings equivalent to 3.0g in the horizontal direction and 2.0g in the vertical direction and to be capable of performing all intended functions, but they were not procured nor analyzed as Seismic I components.

We conclude that the Beaver Valley RVOPS meets the seismic criteria with the exception of the PORV operators. DLC states that an OBE for Beaver Valley is defined as a normalized acceleration of 0.06g and a DBE is defined as a normalized acceleration of 0.125g. This issue is under consideration by the NRC.

3.6 Analysis Results

3.6.1 Mass Input Case

The inadvertent start of a safety injection pump with the plant in a cold shutdown condition was selected as the limiting mass input case.

Westinghouse provided the licensee with a series of curves based on the LOFTRAN analysis of a generic plant design which indicates PORV setpoint overshoot for this transient as a function of system volume, relief valve opening time and relief valve setpoint. These sensitivity analyses were then applied to the Beaver Valley plant parameters to obtain a conservative estimate of the PORV setpoint overshoot. The following assumptions were made when running the analysis:

- 1) One PORV was assumed to fail.
- 2) The RCS was assumed to be rigid with respect to expansion.
- 3) Conservative heat transfer coefficients were assumed for the steam generator.

<u>Parameter</u>	<u>Value and/or Reference</u>
Initial RCS pressure	50 psig
RCS volume	9,716 ft ³
RCS temperature	100°F
PORV relief setpoint	350 psig
PORV opening time	2.5 seconds
SI pump delivery	560 gpm
Mass input rate	77 lb. per second

The PORV setpoint overshoot was determined to be 89 psi. With a relief valve setpoint of 350 psig a final pressure of 439 psig is reached for the worst case mass input transient. The 10 CFR 50 Appendix G curve limit for Beaver Valley is 440 psig for temperatures of 100°F and above. It is concluded that the Beaver Valley RVOPS performance is acceptable for mass input transients.

3.6.2 Heat Input Case

Inadvertent startup of a reactor coolant pump with a primary to secondary temperature differential across the steam generator of 50°F, and with the plant in a water-solid condition, was selected as the limiting heat input case. For the heat input case, Westinghouse provided the licensee with a series of curves based on the LOFTRAN analysis of a generic plant design to determine the PORV setpoint overshoot as a function of RCS volume,

steam generator area and initial RCS temperature. For this transient, the following assumptions were used in the analysis:

<u>Parameter</u>	<u>Value and/or Reference</u>
Initial RCS pressure	300 psig
RCS volume	9,716 ft ³
Initial RCS temperature	100, 180 and 250°F
RCS/Steam generator ΔT	50°F
Steam generator heat transfer area	51,500 ft ²
PORV relief setpoint	350 psig
PORV opening time	3 seconds

The analysis results for the heat input transient depend on the initial RCS temperature; the results for various initial temperatures are given below:

<u>RCS Temperature (F)</u>	<u>P_{max} - P_{setpoint} (psi)</u>	<u>Maximum RCS Pressure (psig)</u>
100	23.7	373.7
180	45	395
250	64.3	414.3

In all these cases, for the given RCS temperature, the Appendix G limits are not exceeded, therefore the performance of the Beaver Valley RVOPS is judged to be adequate for heat induced transients.

4.0 ADMINISTRATIVE CONTROLS

To supplement the hardware modifications and to limit the magnitude of postulated pressure transients to within the bounds of the analysis provided by the licensee, a defense in-depth approach is adopted using procedural and administrative controls. Those specific conditions required to assure that the plant is operated within the bounds of the analysis are spelled out in the Technical Specifications.

A number of provisions for prevention of pressure transients are contained in the Beaver Valley operating procedures. The procedures for startup of a reactor coolant pump require that at RCS temperatures above 160°F, a steam bubble be established in the pressurizer prior to pump start. The steam generator shell-side temperature is monitored to assure that it is within 50°F of the RCS temperature. Also, at least one RCP is

operated throughout a normal cooldown to 160°F to assure that the steam generator follows the RCS temperature.

When RCS temperature decreases to less than 350°F, station shutdown procedures require the isolation of the boron injection tank flow path to prevent overpressurization from a safety injection signal. When RCS pressure decreases to less than 1000 psi the safety injection accumulator discharge isolation valves are closed and the integrity of their discharge check valves is verified periodically. Power is removed from the operators of these valves by disconnecting the control power to the coil of the line-starter by removing jacks in the Control Room. Procedures require placing the RVOPS in service and establishing a nitrogen bubble in the pressurizer as the steam bubble is collapsed. The standby charging pump control switch is placed in the pull-to-lock position at low system temperatures.

5.0 CONCLUSIONS

The administrative controls and plant modifications proposed by Duquesne Light Company provide protection for the Beaver Valley Power Station, Unit 1, from pressure transients at low temperatures by reducing the probability of initiation of a transient and by limiting the pressure of such a transient to below the limits set by 10 CFR 50 Appendix G. We find that the Beaver Valley Reactor Vessel Overpressure Protection System meets GDC 15 and 31 and that DLC has implemented the guidelines of NUREG-0224 except as noted in Sections 3.4 and 3.5 of this report. Pending resolution of these items, the Beaver Valley Overpressure Protection System is judged as an adequate solution to the problem of low temperature overpressure transients.

6.0 REFERENCES

1. NRC letter (Reid) to Duquesne Light Company (DLC), dated August 11, 1976.
2. DLC letter (Dunn) to NRC (Reid), dated October 12, 1976.
3. DLC letter (Dunn) to NRC (Reid), dated December 6, 1976.
4. NRC letter (Reid) to DLC (Dunn), dated January 10, 1977.
5. NRC letter (Reid) to DLC (Dunn), dated February 15, 1977.
6. DLC letter (Dunn) to NRC (Reid), dated March 2, 1977.
7. DLC letter (Dunn) to NRC (Reid), dated April 6, 1977.
8. "Summary of Meeting Held on May 25, 1977, with Westinghouse and the Licensees of Westinghouse Designed PWR Facilities Concerning the Status of their Efforts to Prevent Reactor Vessel Overpressurization", Zech, NRC, dated July 11, 1977.
9. "Pressure Mitigating System Transient Analysis Results" prepared by Westinghouse for the Westinghouse Owner's Group on Reactor Coolant System Overpressurization, dated July 1977.
10. DLC letter (Dunn) to NRC (Reid), dated November 23, 1977.
11. "Reactor Vessel Pressure Transient Protection for Pressurized Water Reactors", NUREG-0224, September 1978.
12. DLC letter (Dunn) to NRC (Schwencer), dated October 4, 1978.
13. DLC letter (Dunn) to NRC (Schwencer), dated December 14, 1978.
14. DLC letter (Dunn) to NRC (Schwencer), dated December 6, 1979.
15. "Technical Evaluation of the Electrical, Instrumentation, and Control Design Aspects of the Low Temperature Overpressure Protection System for the Beaver Valley Nuclear Power Station, Unit 1", prepared for the NRC by Lawrence Livermore National Laboratory, dated June 1980.
16. DLC letter (Carey) to NRC (Varga), dated February 16, 1982.