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SUBJECT: Forwards revised response to Question 1 re NUREG-0737, Item II. D. I, "Performance Testing of Relief & Safety Valves," per 861211 request for addl info.

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June 2, 1987

U.S. Nuclear Regulatory Commission
Document Control Desk
Attn: Mr. Carl Stahle
PWR Project Directorate No. 1
Washington, D.C. 20555

Subject: NUREG-0737, Item II.D.1
Performance Testing of Relief and Safety Valves
R. E. Ginna Nuclear Power Plant
Docket No. 50-244

Dear Mr. Stahle:

An NRC letter dated December 11, 1986 requested additional information to complete the Staff Safety Evaluation on our earlier submittals of relief and safety valve testing. On February 13, 1987 we responded to the NRC Staff request for additional information. Since that time we have had several telephone conversations with Staff members to expand upon and clarify our response to Question 1 of the December 11, 1986 letter.

Attached is a revised response to Question 1 which addresses the concerns expressed in the telecon. It is our understanding that the response to this question is the only remaining open item relative to this topic.

Very truly yours,

Roger W. Kober

Roger W. Kober

Attachment

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Response to NRC Staff Verbal Requests

for Additional Information

NUREG-0737 Item II.D.1

Question 1:

The appendix of RG&E's March 4, 1983 (reference 1) submittal showed the calculation of the inlet piping pressure drop for the Ginna safety valves. The pipe length used in the calculation of the acoustic wave pressure drop was 3.3 ft. (from table A-1 of the appendix). Figure 2-2 in the main body of the same report, however, shows the safety valve inlet piping length to be at least 4.93 ft. This is not the total piping length since the length of at least one portion of the piping was not shown. The additional length could make a significant difference in the calculated acoustic wave pressure drop. Also the calculated flow pressure drop in the same appendix did not account for the 90° bend when calculating the L/D term. Provide the corrected pressure drop with this bend accounted for using the equation found in rev. 2 of the EPRI Submittal Guide (reference 2).

If the recalculated inlet pressure drop for the Ginna Safety valves exceed the pressure drop for the 3K6 test valves, it will be necessary for the ring settings of the Ginna valves to be adjusted so that the valves operate stably.

Response 1:

A review of the pressure drop calculation did uncover discrepancies between the calculation model and the as-built piping configuration. A revised pressure drop calculation follows, using the procedure found in appendix B of the "EPRI PWR Safety and Relief Valve Test Program Guide for Application of Valve Test Program Results to Plant-Specific Evaluations," revision 2.

Each inlet line is analyzed separately, as the pipe lengths and consequently the pressure drop results differ between the valves.

The results of the analysis show that Safety Valve 434 has inlet piping pressure drops below the pressure drop for the 3K6 EPRI test valve for closing and is 14.3% above on opening. Safety valve 435 has inlet piping pressure drops below the pressure drop for the 3K6 valve on closing, and is 14.6% above the 3K6 valve opening.

In the closing mode, the Ginna Station Safety Valves are bounded by the EPRI 3K6 valve. Although the closing mode is more limiting relative to potential valve instability, additional justification for the Ginna design has been developed at the request of the NRC Staff. The additional justification, which is covered in addendum 1, is derived from an earlier safety valve test of a 3K6 valve that Westinghouse, Crosby, and Pacific Gas and Electric Company jointly conducted at Contra Costa in 1967.

A comparison of the Contra Costa tests with EPRI shows that:

a) The steady state inlet pipe pressure drop of the Contra Costa test is roughly double the steady pressure drop of the EPRI test loop (90-120 psi for Contra Costa versus 49 psi for EPRI).

b) The calculated opening plant-specific transient pressure difference accounting for acoustic wave amplitude is higher for Contra Costa than either the EPRI or the RGE (Ginna) loop.

Since the Contra Costa valve (3K6) operated successfully during the test, it is concluded that the EPRI acoustic pressure values can be exceeded by up to 18% and still operate satisfactorily. This 18% value envelopes the 14.6% value for the Ginna safety valves and confirms their acceptability.

Operation of the 3K6 valve during the EPRI tests was, on opening, stable with minor fluctuations during loop seal discharge. This is considered normal and expected operation for this type of valve, when discharging low temperature loop seal water (T = 100°F). The higher loop seal temperature such as exists at RGE (T >340°F) would be expected to reduce or eliminate the flutter. Figures 3 and 4 display the plots of the 3K6 valve Contra Costa test results (test run 2). Note that the 3K6 valve is the same EPRI valve model that the Ginna relief valve evaluation has been

based on. Valve inlet pressure, outlet pressure and lift were recorded in the opening and closing directions. As shown, minor pressure fluttering was observed on the inlet pressure during the valve opening. The valve inlet pressure quickly stabilized during the blowdown test. The total test time was 1 minute and 35 seconds.

For these reasons the Ginna 4K26 valves are expected to operate stably without adjustment.

ADDENDUM 1

Introduction

This addendum provides a technical basis for accepting the RGE safety valve opening pressure drops. The central issue being addressed in this addendum is the justification for stating in RG&E's February 13, 1987 submittal from R. W. Kober to G. E. Lear that the Ginna 4K26 safety valves would not be affected when the plant acoustic pressure drop is shown to exceed the recommended EPRI value by 14.6% during opening.

To respond to this issue, data is used from earlier relief valve testing that Westinghouse and Crosby conducted on Crosby relief valves in 1967. These tests involved steam relief of 3K6 valves at a facility in Contra Costa, California. The tests were conducted from October to December 1967. The test loop is shown in Figure 1. As shown, there was a loop seal in this system. The test involved recording the set pressure, reset pressure, flow rate, stroke and response times of the valves.

The objective of the Contra Costa test was to confirm the ability of the relief valves to perform their operational relieving function at design conditions. The Crosby valve (3K6) was pressure popped for a total of seven (7) cycles with various guide and nozzle ring adjustments to obtain the valve operational limits on the test loop. The results of typical test cycles as reported in Crosby Test Report No. 2387 are tabulated in Table 1.

The drum to valve pressure drop ranged from 100-120 psi at open and 90-100 psi at close. The safety valve with this pressure drop responded satisfactorily. The details of this test and the results are covered in Crosby Test Report No. 2387, Reference 1.

In order to verify the validity of using the Contra Costa data, the following points were discussed with Crosby.

A. Crosby Ring Setting Procedure

The use of a consistent ring setting procedure between Contra Costa, RGE and other valves they produce is necessary to establish the applicability of the Contra Costa test.

On 4/10/87, Westinghouse (Ike Ezekoye) discussed this issue with Mr. Richard (Dick) Zahorsky, Chief Engineer at Crosby. Mr. Zahorsky stated that Crosby has maintained and used the same ring setting procedure on their valves from the earliest date that the company began to build relief valves. Rings are set from the highest locked position of the rings. Because of production tolerances, there is considerable variability between the ring settings from one valve to another of the same model. In general, Crosby states that the guide ring is the primary guide ring that actually affects blow down. Crosby cautioned that the EPRI ring setting procedure differed from the Crosby approach in that EPRI set the rings from a level position as against Crosby's approach of setting from the highest locked position. Therefore, the EPRI

settings are not directly comparable numerically to the Crosby settings. However, the Crosby ring setting procedure has been consistently maintained.

B. Backpressure Effect

Crosby was asked to comment on the effect of backpressure on valve performance, given that the Contra Costa valve relieved directly to the stack. Referring to the Contra Costa plots (attached), the backpressure varied between 40 psi to 60 psi. EPRI data (EPRI NP-2770-LD, vol. 5, Table 4-2, pp 4-3 to 4-4) show that backpressures on the 3K6 valve during the EPRI test varied from 140 psi (run 425) to 860 psi (run 415). Crosby (Dick Zahorsky) remarked that:

1. The bellows design employed in the 3K6 valve minimizes the effect of backpressure on the valve performance as evidenced by the fact that a high backpressure of 860 psi did not affect the valve performance in run 415.

2. The fact that the 3K6 valve performed well with back-pressures up to 860 psi confirms the insensitivity of the design to high backpressures. The low backpressure at Contra Costa has no effect on the valve performance.

Based on these discussions, the Contra Costa data can be used to evaluate the performance of the 3K6 valves.

Analysis

The following analysis is supplemented as necessary with information contained in various EPRI documents which are referenced. Together, these documents provide the necessary data to support the position that the estimated 14.6% higher total inlet acoustic pressure drop for RGE relief valves would not affect valve relieving in the opening mode.

An EPRI document, "EPRI PWR Safety and Relief Test Program Guide for Application of Valve Test Program Results to Plant-Specific Evaluations," provides guidelines for plant-specific evaluation of EPRI results (reference 2). One of the guidelines suggested for assuring EPRI test results are applicable for each plant valve arrangement is the estimation and comparison of plant specific pressure drops between the pressurizer and the relief valve with EPRI recommended limits.

The significant pressure drops are:

a) steady state pressure drop
b) total acoustic wave pressure drop

In this evaluation, these pressure drops for the Crosby 3K6 relief valve both for the EPRI safety valve arrangement and the Contra Costa safety valve arrangement are calculated. Since the 3K6 valves performed satisfactorily during the Contra Costa and

EPRI tests, the EPRI pressure drop estimates are determined to be conservative. The Contra Costa tests show that a higher pressure drop bound can be established. Therefore, the Ginna valves are expected to perform properly.

Acoustic Wave Effect on Pressure Drop

The EPRI test arrangement is shown in Figure 2. A first step in the pressure drop calculation per reference 2 is the determination of the acoustic wave reflection time (2L/a). Comparing the acoustic wave reflection time with the valve stroke time, T, leads to the set of formulas that can be used for pressure drop estimates. Both the EPRI arrangement and Contra Costa arrangement would require the same set of formulas because in both cases the acoustic wave reflection times are higher than the valve stroke time. The acoustic wave reflection time is given by:

$$T_a = 2\ L/a \qquad (1)$$

where: a = acoustic velocity

$L = \Sigma_n \ell_n$

ℓ_n = the length of any flow element between the closest reflection point (i.e., pressurizer) and the relief valve inlet.

Thus from the EPRI inlet piping arrangement (figure 2)

$L = 9.3812$ feet

$a = 1100$ fps

$$T_a = \frac{2L}{a} = .0171 \text{ secs.}$$

The valve stroke time in the opening direction (from ref. 2) is:

$T = .010$ seconds

Thus, $T_a > T$ (i.e., the valve stroke time T is faster than the wave reflection time T_a)

Thus, as described in Ref. 2 both the steady state pressure drop and the transient acoustic wave amplitude are independent of the upstream wave effects for the EPRI tests.

Figure 1 shows the layout of the Contra Costa test loop. At Contra Costa, the pipe length from the drum to the test valve was approximately 22.9 feet as compared to the Ginna total pipe length of 5.974 feet.

Using equation 1 for the Contra Costa and Ginna pipe lengths yields the following:

Contra Costa; $T_a = \frac{2L}{a} = \frac{2(22.9)}{1100} = 0.0416$ seconds

Ginna; $T_a = \frac{2L}{a} = \frac{2(5.974)}{1100} = 0.01086$ seconds

In both cases T_a is greater than T which leads to the same conclusion on the choice of EPRI formulas for pressure drop estimation.

Therefore, it has been determined that, in both the Contra Costa case and the EPRI case, the pressure drops are not affected by upstream acoustic wave effects. Thus, the following formulas specified by Reference 2 apply to both cases.

$$\Delta P_{\text{steady state}} = (K + f\,\frac{L}{D})\,(C\dot{M})^2/2g_c\rho A^2 \qquad (2)$$

$$\Delta P_{\text{acoustic wave}} = a\,(C\dot{M})^2/g_c A + (C\dot{M})^2/2g_c\rho A^2 \qquad (3)$$

$$\Delta P_{\text{total}} = \Delta P_{\text{steady state}} + \Delta P_{\text{acoustic wave}} \qquad (4)$$

These pressure drops are estimated below.

<u>EPRI Pressure Drops</u>

a) Steady State Pressure Drop

The steady state pressure drop is the average of the difference between the tank pressure and the relief valve inlet during the valve stable region at or around 2485 psi. Table 2 shows the steady state pressures from various EPRI tests.

b) Acoustic Pressure Drop Amplitude (P_{aw})

The total acoustic pressure drop per EPRI is 391 psi for 3K6 (reference 2). Thus, the acoustic pressure amplitude:

$$P_{aw} = 391 - \Delta P_f = 391 - 49 \text{ psi}$$
$$= 342 \text{ psi}$$

Contra Costa Pressure Drops

a) Steady State - The steady state pressure drop is $\Delta P_f = 90$ to 120 psi (reference 1).

b) Acoustic Pressure Drop Amplitude (P_{aw})

We note that the P_{aw} equation (i.e., equation 3) is valve specific and hence:

$$P_{aw}/\text{Contra Costa} = P_{aw}/\text{EPRI} = 342 \text{ psi}$$

By definition $P_t = P_{aw} + P_f$

Thus the total acoustic pressure drop P_t lies between 432 psi (i.e., 342 + 90) and 462 psi (i.e., 342 + 120).

Analysis Summary

Table 3 summarizes the results. It shows that the EPRI value for total acoustic pressure drop is conservative. The fact that satisfactory performance was obtained from the Contra Costa valve in spite of the fact that its acoustic wave pressure drop exceeded the EPRI value confirms this. The range of pressure drop ratios from the Contra Costa tests (1.105 to 1.182) provide evidence that satisfactory valve operation was obtained at ratios both above and below the Ginna value of 1.146. Since the ratio of RGE and EPRI pressure drops (1.146) lies below the ratio of Contra Costa and EPRI value (1.18) it has been established that the increased pressure drop would not affect RGE safety valves during the opening mode.

TABLE 1

CONTRA COSTA TEST RESULTS OF 3K6 VALVE

Cycle No.	Ring N.R.	Pop Settings G.R.	Reseat Pressure psi	Pressure psi	Blowdown psi	Blowdown Time	Remarks
1	- 6	- 145	2470	2240	230	2 min.	Good operation
4	- 8	- 125	2440	2300	140	-----	Good operation
6	- 8	- 125	2470	2290	180	1 min. 10 sec.	Good operation
7	- 8	- 125	2450	2300	150	54 sec.	Good operation
2	- 14	- 145	2490	2250	240	1 min. 35 sec.	Good operation. Valved opened sharp and clean. High lift press. drop drum to valve at pop 100 + psi and at reseat 90 psig. Drum pressure at reseat 2340.

Note: N.R. stands for nozzle ring.
G.R. stands for guide ring.

TABLE 2

SUMMARY OF EPRI STEADY STATE PRESSURE DROPS

Valve Run	Time* (Secs)	ΔP_f(psi)	Reference Figures from EPRI NP-2770-LD Vol. 5 (Reference 4)
525	39	52	6-438 and 6-440
526	45	50	6-461 and 6-494
529	99.8	45	6-484 and 6-486

Average ΔP_f = 49 psi

*The time in the test when the tank pressure was around 2485 psi.

TABLE 3

SUMMARY OF AVAILABLE TESTS AND ANALYSIS RESULTS ON 3K6

	Contra Costa	EPRI	RGE	ΔP ratio Contra Costa / EPRI	ΔP ratio RGE / EPRI
ΔP (psi)					
Steady State	90→120	49	52.15	1.726→2.30	1.064
$P_t + \Delta P_f + \Delta P_w$ (psi)	432→462	391	448.04	1.105→1.182	1.146

References

1. "Report of Tests of Crosby Style HB Valves on Loop Seal for Westinghouse Electric Corporation Nuclear Energy Systems at Pacific Gas and Electric Company, Contra Costs Plant Test Site, Contra Costa, California," Crosby Valve and Cage Company, Test Report No. 2387, dated 1969.

2. "EPRI PWR Safety and Relief Valve Test Appendix B of Program Guide for Application of Valve Test Program Results to Plant-Specific Evaluations," by T. E. Auble and J. F. Hosler.

3. "Ginna Station Pressurizer Safety Valve Inlet Piping Pressure Drop Calculation, V-EC-248" by S. R. Shaw.

4. EPRI/C-E PWR Safety Valve Test Report Volume 5: Test Results for Crosby Safety Valve, EPRI NP-2770-LD Volume 5.