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SUBJECT: Forwards response to NRC 840705 request for addl info re NUREG-0737,Item II.D.1 concerning performance testing of relief & safety valves.

"See Repts"

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NRC TAC #44616

Director of Nuclear Reactor Regulation
Attention: Mr. Steven A. Varga, Chief
Operating Reactors Branch No. 1
Division of Licensing
United States Nuclear Regulatory Commission
Washington, DC 20555

H. B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2
DOCKET NO. 50-261/LICENSE NO. DPR-23
RESPONSE TO REQUEST FOR ADDITIONAL
INFORMATION ON NUREG-0737, ITEM II.D.1

Dear Mr. Varga:

Attached for your information are Carolina Power & Light Company's responses to your request for additional information dated July 5, 1984 concerning performance testing on relief and safety valves.

Please contact Mr. Stephen D. Floyd at (919) 836-6901 if you have any questions concerning our responses.

Yours very truly,

S. R. Zimmerman
Manager
Nuclear Licensing Section

SDF/ccc (796SDF)

Attachment

cc: Mr. J. P. O'Reilly (NRC-RII)
Mr. G. Requa (NRC)
NRC Resident Inspector (RNP)

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PDR ADOCK 05000261
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SAFETY EVALUATION QUESTIONS AND RESPONSES

TMI ACTION NUREG-0737 II.D.1

FOR H. B. ROBINSON UNIT 2

Questions related to selection of transients and inlet fluid conditions:

Question 1

The Westinghouse valve inlet fluid conditions report stated that liquid discharge through the Safety and Power Operated Relief Valves (PORVs) is predicted for an FSAR feedline break event. The Westinghouse report gave expected peak pressure and pressurization rates for some plants having a FSAR feedline break analysis. The H. B. Robinson Unit 2 plant was not included in this list of plants having such a FSAR analysis. Nor does the H. B. Robinson plant-specific submittal address the FSAR feedline break event. NUREG-0737, however, requires analysis of accidents and occurrences referenced in Regulatory Guide 1.70, Revision 2, and one of the accidents so required is the feedline break. Provide a discussion on the feedwater line break event, identifying the fluid pressure and pressurization rate, fluid temperature, valve flow rate, and time duration for the event. Assure that the fluid conditions were enveloped in the EPRI tests or other tests and demonstrate operability of the safety and relief valves for the time duration of this event. Further, assure that the feedline break event was considered in analyses of the safety/relief valve piping system.

Response

The feedline break accident is not part of the H. B. Robinson licensing basis. Nuclear plants such as H. B. Robinson were licensed prior to issuance of Regulatory Guide 1.70, Revision 1, and were not required to consider the feedline break as part of their design basis.

(796SDF/ccc)

Question 2

In valve operability discussions on cold overpressurization transients, the submittal only identifies conditions for water discharge transients. According to the Westinghouse valve inlet fluid conditions report, however, the PORVs are expected to operate over a range of steam, steam-water, and water conditions because of the potential presence of a steam bubble in the pressurizer. To assure that the PORVs operate for all cold overpressure events, discuss the range of fluid conditions for expected types of fluid discharge and identify the test data that demonstrate operability for these cases. Since no low pressure steam tests were performed for the relief valves, confirm that the high pressure steam tests demonstrate operability for the low pressure steam.

Response

EPRI test conditions were chosen based on expected inlet conditions for the subject valves. Tests were limited, but designed to confirm operability over the full range of expected inlet conditions. Steam, steam to saturated water, nitrogen to water, and water flow tests were conducted. Although the steam test was conducted only at the higher pressure, it is expected that satisfactory operation would also result at lower pressures. This is somewhat confirmed by the successful low pressure (675 psia), low temperature (105-442°F) water tests.

Saturated water to subcooled water, and steam to saturated water are additional valve inlet conditions which may occur during cold overpressurization events. Valve operability for these conditions were not specifically demonstrated by the EPRI tests, but saturated steam, subcooled water, and saturated water tests were conducted separately by EPRI. It is therefore expected that satisfactory valve performance would result if these conditions were to be tested in sequence.

Question 3

Results from the EPRI tests on the Crosby safety valves indicate that the test blowdowns exceeded the design value of 5 percent for both "as installed" and "lowered" ring settings. If the blowdowns expected for the plant (see Question 4) also exceed 5 percent, the higher blowdowns could cause a rise in pressurizer water level such that water may reach the safety valve inlet line and result in a steam-water flow situation. Also, the pressure might be sufficiently decreased such that adequate cooling might not be achieved for decay heat removal. Discuss these consequences of higher blowdowns if increased blowdowns are expected.

Response

Blowdowns in excess of 5 percent have been analyzed in conjunction with the Westinghouse Owners Group (WOG) program on safety valves. The analyses utilized valve blowdowns in excess of 10 percent. The results from these analyses showed no adverse effects on plant safety. The peak pressurizer water level calculated remained below the pressurizer inlet piping to the safety and relief valves.

Question 4

The submittal states that the limiting extended high pressure injection transient for this plant was the spurious activation of the safety injection system at power. The submittal also states that the high head injection pump cutoff head is 1500 psi and that liquid discharge through the safety valves is therefore not expected for a high pressure injection transient. The submittal does, though, present a table showing inlet fluid conditions for a PORV discharge resulting from high pressure injection. The cutoff head of 1500 psi, however, should preclude an actuation of the PORVs, which have a set pressure of 2350 psia. Provide a clarification of this apparent discrepancy.

Response

H. B. Robinson does have a high head injection pump, which has a cutoff head of 1500 psia. Therefore, no discharge is expected through either the safety or the relief valves as the result of a spurious initiation of the high pressure injection system. Table 3-2 as it appears in the submittal is incorrect and should state "No Discharge" for both the safety and relief valves.

(796SDF/ccc)

Questions related to valve operability:

Question 5

The submittal states that the safety valve ring settings determined during the EPRI tests represent the adjustment required to provide stable operation for a particular valve when exposed to particular test conditions. It further states that the ring positions for valves installed at H. B. Robinson were set by the valve manufacturer to operate on a 7-10 ft. loop seal. Since the H. B. Robinson loop seal is of this length, the submittal concludes that stable valve performance will likely result. The submittal does not, however, provide the specific plant ring settings, which can be compared with those used in the EPRI valves. Since EPRI tests on the Crosby 3K6 and 6M6 safety valves were used to evaluate performance of the 4K26 valve of H. B. Robinson, explain which ring settings on the 3K6 and 6M6 valves would correspond with those used on the 4K26 valve. Identify the expected blowdowns corresponding to the plant ring settings and calculated backpressures and explain how these blowdowns were extrapolated or calculated from test data. Verify that the valves will operate properly with the expected backpressures and blowdown and other fluid conditions occurring at the plant.

Response

Ring settings for the H. B. Robinson safety valves, as shipped by the valve manufacturer, Crosby, are as follows:

Valve	N. R.	G. R.
RV-551-A	-7	-250
RV-551-B	-7	-250
RV-551-C	-7	-250

Please note that the ring settings indicated above were measured by Crosby from the "highest" locked position as noted in Crosby procedures and in the EPRI reports definition of key terms and parameters and not as measured from the "level position" as the ring settings reported by EPRI.

Ring settings for the H. B. Robinson 4K26 safety valves were developed by Crosby during production testing of the valves; therefore, no equivalent ring settings for the Crosby 3K6 and 6M6 valves need to be provided. Blowdowns measured in the Crosby production testing for each valve were equal to or less than 5 percent. The dynamic backpressures measured during the EPRI tests were approximately 9-29 percent of the setpoint; however, Crosby valves employ a balanced bellows design that is relatively insensitive to backpressure effects as noted by EPRI on page S-5 of EPRI Report NP-2770-LD, Volume 5. The blowdown and backpressure effects, therefore, will not impact valve functionability.

Question 6

Results from EPRI tests on the Crosby 3K6 and 6M6 safety valves were used to evaluate performance of the Crosby 4K26 valve of H. B. Robinson. The EPRI test results indicate that steam flow rates in excess of rated flow were achieved. A flow rate determination for the H. B. Robinson valves, however, depends on specific ring settings used at the plant. Thus, provide a demonstration that the plant safety valves will pass their rated flow at the ring settings used.

Response

As noted in Table 4-4 of EPRI report NP-2770-LB, Volume 6, the Crosby 6M6 test valve achieved rated flow for each of the tests reported at 3 percent accumulation regardless of the ring setting used in the test. A review of EPRI Tables 4-3 and 4-4 in Volume 5 of EPRI report NP-2770-LD reveals that for steam tests of the 3K6 valve where blowdown was measured to be less than 10 percent, flow rates of 119-122 percent of rated flow at 3 percent accumulation were reported. The EPRI tables indicate that lower than rated flows occurred at blowdowns greater than 15 percent. As stated in the response to NRC Question 5, the Crosby production testing for the 4K26 valve has determined that the H. B. Robinson ring settings will provide blowdowns of 5 percent for the safety valves. This is within the range of both the 3K6 and 6M6 tests where rated flow was achieved; therefore, rated flow can be expected for the H. B. Robinson 4K26 valves.

Question 7

During an EPRI loop seal steam to water transition test on the 3K6 valve, the valve fluttered and chattered when the transition to water occurred. The test was terminated after the valve was manually opened to stop chattering. The 6M6 valve exhibited similar behavior on two loop seal-steam tests and one subcooled water test. Again, these tests were terminated after the valve was manually opened to stop chatter. Justify that the valve behavior exhibited in these tests is not indicative of the performance expected for the H. B. Robinson valves. Potential liquid flow through the plant safety valves cannot be disregarded unless the feedline break event is shown to be nonapplicable to this plant (see Question 1).

Response

Testing conducted by EPRI was designed to envelop numerous plant specific conditions of piping arrangement, inlet fluid conditions and valve types. Because worst case conditions were tested, adjustments had to be made to the test valves to obtain stable performance during the tests. This sometimes resulted in ring settings outside the normal "as shipped" range and blowdowns in excess of 5 percent. As stated in the response to Question 5, ring settings for the H. B. Robinson valves were established by Crosby during production tests and were reported to result in blowdowns of 5 percent. The test results reported by EPRI, therefore, may not be directly applicable to the H. B. Robinson valves and consideration should be given to the effects of these adjustments.

The 3K6 steam-to-water transition test was conducted using ring settings that resulted in blowdowns in excess of 15 percent and is, therefore, not considered representative of the ring settings specified for the H. B. Robinson valves which result in 5 percent blowdown and stable valve performance.

The two 6M6 loop seal steam tests 920 and 1419 which ended in valve chatter were repeats of two other successful steam tests 917 and 1415. Close examination of these tests reveals that for each test the safety valve opened on demand, relieved the test system pressure transient for approximately 20 seconds, reduced the initial pressure by 4-5 percent as required and then closed. Upon closing, the valve reopened only on tests 920 and 1419 and chattered. Valve inlet pressure plots show that pressure oscillation at the valve inlet which vary from the magnitude of the set pressure to the blowdown pressure, drove the valve to chatter. These pressure oscillations are acoustic in nature and are due to the long loop seal piping length tested by EPRI. As the H. B. Robinson loop seals are shorter than those tested by EPRI, more stable results can be expected at H. B. Robinson. In addition, the H. B. Robinson valve and piping arrangement is better represented by the 3K6 test valve arrangement.

The Crosby 6M6 test valve experienced chattering during the 500°F subcooled water test. This is not unexpected as spring loaded safety valves such as the Crosby 6M6 and 4K26 are designed to operate on steam and rely on the fluid expansion for proper operation. Subcooled water relief is provided by the H. B. Robinson PORV's.

Question 8

Bending moments are induced on the safety valves and PORVs during the time they are required to operate because of discharge loads and thermal expansion of the pressurizer tank and inlet piping. Make a comparison between the predicted plant moments with the moments applied to the tested valves to demonstrate that the operability of the valves will not be impaired.

Response

The bending moments induced on the safety and relief valves tested by EPRI exceeded the bending moments predicted for the H. B. Robinson safety and relief valves. The maximum moment tested for the 6M6 valve was during test 908 and was 298.75 in-K. The largest moment predicted at the safety valves for H. B. Robinson is 97.755 in-K, thus demonstrating functionability for the H. B. Robinson safety valves.

Likewise, a bending moment of 43.0 in-K was induced in the inlet of the Copes-Vulcan PORV test valve per test EPRI 64-CV-174-2S. The largest bending moment predicted in the H. B. Robinson relief valves is 35.703 in-K, thus demonstrating functionability for the H. B. Robinson relief valves.

Question 9

The submittal in Table 2-3 provides a comparison between the calculated inlet piping pressure drop for the plant-specific Crosby 4K26 safety valve and the inlet piping pressure drops for the Crosby 3K6 and 6M6 EPRI test valves. The values of the pressure drops for the test valves are reported as being taken from the report EPRI PWR Safety and Relief Valve Test Program Guide for Application of Valve Test Program Results to Plant-Specific Evaluations, July 1982. The EPRI report available to EG&G is Revision 1, March 1982. The pressure drop values from Revision 1 do not correspond to the values reported in the submittal. Comparison of the values in Revision 1 of the report would indicate that the pressure drop of the inlet piping for the plant-specific valve exceeds the pressure drop for both test valves. This would normally indicate that the test inlet piping is not a conservative representation of the plant piping. Also, the transient flow pressure difference calculation in the submittal used zero for the summation of the expansion and contraction coefficient. The zero value does not seem appropriate for the pressurizer to nozzle area change and use of zero is non-conservative. Provide additional information clarifying the apparent discrepancy or provide other justification that the tests on the Crosby 3K6 and 6M6 valves are adequate for demonstrating the performance of the H. B. Robinson Crosby 4K26 valve.

Response

Values for 3K6 and 6M6 loop seal pressure drops were taken from Revision 2 of the EPRI S/RV test Program Guide (attached), Table B-3. Although the H. B. Robinson pressure drops were calculated to be in excess of that reported by EPRI for the test arrangements, the H. B. Robinson piping configuration is similar to the EPRI arrangement and the pressure drop is within 4 percent of the test opening and within 9 percent of the closing pressure drop. Therefore, the data for the 3K6 valve can be extended to the H. B. Robinson valve. As for the comment concerning use of a zero value for the pressurizer to inlet pipe contraction coefficient, this guidance comes from the EPRI Note on page B.2 of the above mentioned submittal under "K" value definition. This note states the loss coefficient can be amended to be zero for this calculation. Indeed if a comparison is to be made between plant-specific calculated pressure drops and the EPRI calculated test pressure drops, the same assumptions must be made in both calculations.

Question 10

The submittal indicates that liquid flow through the PORVs can be expected for at least the extended high pressure injection event and the cold overpressurization event. The EPRI/Marshall PORV block valve testing program, however, did not include tests on the block valves with fluid media other than steam. Provide a justification as to how results of the Marshall tests or other tests can be used to demonstrate operability of the block valves for liquid conditions. Also, evaluate applicability of the test results to the H. B. Robinson block valve since the plant valve has a Limitorque SMB-000-5 operator while an SB-00-15 operator was tested.

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 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.

As noted in the block valve submittal, two differences exist between the H. B. Robinson block valves and those tested by EPRI. First, the motor operator installed on the H. B. Robinson block valves is a Limitorque SMB-000-5 versus the Limitorque SB-00-15 operator used with the EPRI test valve. Also, the speed of the two valves is different, 40 seconds for the H. B. Robinson valve and 10 seconds for the EPRI valve. The report also states the H. B. Robinson block valves provide an output thrust that exceeds that required to close the valves by approximately 35 percent.

Since the valves at H. B. Robinson are of similar design except for the motor operators (the operators are different due to the required closing times) to the one tested by EPRI and the output thrust is greater than required, the valves at H. B. Robinson should exhibit performance equal to or better than the EPRI test valves.

Question relating to thermal hydraulic and structural analysis of inlet and discharge piping:

Question 11

The report concerning safety and PORV line evaluation gives three general upstream environments for valve opening cases that are supposed to envelope the commercial scenarios. List the inlet fluid conditions used in the analyses to represent these cases, so that it can be confirmed that all limiting transients were enveloped. Assure that the main feedline break event, which is a liquid discharge case, was enveloped.

Response

During normal operation, a water seal exists upstream of the PORV's. The piping between the pressurizer nozzle and the tee at Node #4070 (see Figure 6-2 of the submittal for an illustration of the upstream PORV piping) is steam-filled. The piping from the tee to each PORV is water-filled. The limiting discharge case for PORV actuation is discharge of the water slug, not steam discharge or not cold-overpressurization water-solid discharge. The initial inlet fluid conditions for the water slug PORV discharge case utilized in the specific H. B. Robinson #2 thermal hydraulic analysis are:

Steam phase: h = 1162.4 btu/lb, P = 2350 psia
Water phase: h = 123.7 btu/lb, P = 2350 psia

During normal operation, a hot loop seal exists upstream of each safety valve. The piping between each pressurizer nozzle and each loop seal is steam-filled (see Figure 6-1 of the submittal). The limiting discharge case for safety valve actuation is discharge of the loop seal. Water solid discharge through the safety valves is not included in the design basis (see response to Question 1). The initial inlet conditions used in the hot loop seal safety valve discharge analyses are: P = 2575 psia, h (steam phase) = 1110 btu/lb.

As noted in the submittal, the loop seal temperature profile was assumed to have the same distribution as EPRI Test 917. That is, the water temperature at the valve was 300°F, and was at system saturation temperature near the steam/water interface.

Question 12

The submittal does not present sufficient detailed information to allow for a complete evaluation of the structural analysis. It does state that the time-history solution was found using the FIXFM3 Program and that internal forces and deflections were determined by the WESTDYN2 Program. The dynamic solution to fluid loads was obtained by using a modified predictor-corrector integration technique and normal mode theory. Provide a more detailed description of this solution technique. Additionally, describe methods used to model the connections to the pressurizer and relief tanks.

Response

As noted in the submittal, the major structural analyses programs utilized in the static and dynamic analyses were 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 is 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, page 193-199.

In the modeling of the H. B. Robinson #2 pressurizer safety and relief valve piping, the pressurizer nozzles and pipe connections were represented with appropriate pipe properties. Intensification at the nozzle to pipe welds was included. The pressurizer nozzles were connected to a rigid link anchored at the pressurizer centerline. The downstream piping terminated at the sparger piping inside the relief tank. The piping was anchored at the relief tank centerline.

Question 13

According to results of EPRI tests, high frequency pressure oscillations of 170-260 HZ typically occur in the piping upstream of the safety valve while loop seal water passes through the valve. The submittal refers to an evaluation of this phenomenon that is documented in the Westinghouse report WCAP-10105 and states that the acoustic pressures occurring prior to and during safety valve discharge are below the maximum permissible pressure. The study discussed in the Westinghouse report determined the maximum permissible pressure for the inlet piping and established the maximum allowable bending moment for Level C Service Conditions in the inlet piping based on the maximum transient pressure measured or calculated. While the internal pressures are lower than the maximum permissible pressure, the pressure oscillations could potentially excite high frequency vibration modes in the piping, creating bending moments in the inlet piping that should be combined with moments from other appropriate mechanical loads. Provide one of the following: (1) a comparison of the allowable bending moments established in WCAP-10105 for Level C Service Conditions with the bending moments induced in the plant piping by dynamic motion and other mechanical loads or (2) justification for other alternate allowable bending moments with a similar comparison with moments induced in the plant piping.

Response

The H. B. Robinson #2 piping system response including the safety valve loop seal region is due to frequencies less than 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 also much less than this (170-260 HZ) range. Industry data indicates that frequencies of 100 HZ or less are meaningful. The EPRI 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 deadweight and 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 through 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 allowable. Specifically, the maximum allowable moment from Table 4-7 of WCAP-10105 for 4-inch schedule 120 piping for an internal pressure of 5000 psi is 143 in-kips. The moments for the sum of deadweight and water slug discharge for the components listed in Table 6-14 of the submittal at nodes 2050, 3020, and 1030, respectively, are 42.0, 84.4 and 70.9 in-kips.

Question 14

The submittal provides a stress evaluation for the upstream and downstream piping for various loading combinations. The calculated stresses are shown to be lower than ANSI B31.1-1967 Code allowables. Subsequent to these calculations, the temperatures in the loop seal were discovered to be below the temperature assumed in the analysis. The submittal indicates that the loop seal is being evaluated for potential modifications to raise its temperature to the range assumed in the analysis. Provide the results of this evaluation and describe any modifications required.

Response

Evaluation of the loop seals resulted in the decision to enclose each in an insulated box. The boxes were designed to make the loop seals temperature profiles consistent with the Westinghouse assumptions. The boxes are each internally heated by a partially exposed area of the pressurizer that forms one wall of the box. The installation of the boxes is complete.

Question 15

While the stress evaluations in the submittal address the stresses in the upstream and downstream piping they do not make any conclusions concerning the pipe supports. The letter L. W. Eury to S. A. Varga dated December 28, 1982, indicates that the support loads calculated as of that time may have exceeded design values. Provide a final evaluation of support adequacy reflecting the lower loop seal temperatures or modifications made to the loop seal (see Question 14) and describe modifications to the supports if any.

Response

The design load capacities of the system pipe supports were checked against the loads predicted by the Westinghouse stress evaluation. Supports that could not accommodate the Westinghouse loads were redesigned to do so. Required support modifications have been completed. The Westinghouse hot loop seal assumption is valid (see Question 14 response).

Question on PORV Circuitry

Question 16

NUREG-0737, Item II.D.1 requires that the plant-specific PORV control circuitry be qualified for design-basis transients and accidents. Please provide information which demonstrates that this requirement has been fulfilled.

Response

Pressurizer PORVs (PCV-456 and PCV-455C) position indication have been classified as C-3 and D-2 variables per Regulatory Guide 1.97, Revision 3. New ASCO NP831655E solenoid valves are to be installed for both PORVs. These solenoid valves are fully qualified for design basis transients and accidents. The H. B. Robinson schedule for compliance with Regulatory Guide 1.97 will be submitted in December 1984.

(796SDF/ccc)