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U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D. C. 20555

Subject: Catawba Nuclear Station, Units 1 and 2
Docket Nos. 50-413 and 50-414
NRC Request for Additional Information On
Performance Testing of Relief and Safety Valves

Gentlemen:

Dr. K. N. Jabbour's letter of July 31, 1987 transmitted a request for additional information regarding the performance testing of relief and safety valves (Item II.D.1 of NUREG-0737). These questions were based on Duke Power Company submittals dated October 26, 1983 and February 3, 1984. Please find attached Duke Power's responses to the subject questions. It should be noted that Duke Power personnel are in the process of evaluating Question No. 8 and that an additional response will be provided prior to May 31, 1988.

Very truly yours,

Hal B. Tucker

Hal B. Tucker

JGT/12/sbn

Attachment

xc: Dr. J. Nelson Grace, Regional Administrator
U. S. Nuclear Regulatory Commission
Region II
101 Marietta Street, NW, Suite 2900
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Mr. P. K. Van Doorn
NRC Resident Inspector
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QUESTION 1. Safety Valve Inlet Pressure Drop

The EPRI Test conditions Report stated that a method of demonstrating safety valve stability is to compare the total pressure drop of the inlet piping for the plant safety valve with the total pressure drop of the inlet piping for the EPRI test valve. The total inlet piping pressure drop is comprised of a frictional and acoustic wave component evaluated under steam conditions. Provide this comparison of inlet piping pressure drops for valve opening and pressure rise for valve closure.

RESPONSE: The safety valve inlet pressure drop was calculated in accordance with the methodology presented in EPRI Application Guide, Revision 2. An acoustic wave plus a friction pressure drop was calculated for the worst case inlet pipe both for valve opening and closing. The values calculated are approximately the same as the short inlet pipe configuration used by EPRI for the Dresser 31739A valve, which exhibited satisfactory performance in all tests. The total transient pressure drops calculated for Catawba are.

Valve opening - 264 psi

Valve closing - 9 psi

QUESTION 2. Backpressure

The submittal stated the maximum backpressure was calculated for the Catawba discharge piping but the backpressure calculated was not provided and was not compared to the maximum backpressure developed in the discharge piping during the EPRI tests. Since the EPRI tests show that safety valve performance is sensitive to backpressure, backpressure should be considered in the safety valve evaluation. Provide the numerical value of the calculated maximum backpressure for the Catawba safety valves and explain how the backpressure was calculated.

RESPONSE: The maximum Catawba backpressure calculated was 652 psig. The pressure was calculated from the RELAP 5 analysis.

QUESTION 3. Cold Overpressure Transient

In the discussion of the PORV inlet fluid condition for cold overpressure transients, the Licensee indicated the temperature range expected at the PORV inlet for both the low and high pressure setpoints but did not give the maximum pressure calculated to occur during a cold overpressure transient. Identify the maximum pressure predicted for the cold overpressure transient so as to complete the cold overpressure discussion.

RESPONSE: The maximum pressure predicted to occur under cold overpressure conditions is 489 psig.

QUESTION 4. PORV Control Circuitry

As noted in the introduction, NUREG-0737, Item II.D.I, required qualification of the PORV control circuitry. The Nuclear Regulatory Commission staff has agreed that meeting the licensing requirements of 10CFR 50.49 for this circuitry is satisfactory and that specific testing per NUREG-0737 requirement is not required. Therefore verify whether the PORV control circuitry has been reviewed and accepted under the requirements of 10CFR 50.49.

RESPONSE: The electrical components and associated PORV control circuitry meet the requirements of 10CFR 50.49.

QUESTION 5. Valve Ring Settings

Reference 1 indicated the ring settings for the Catawba 1&2 Dresser 31749A safety valves were determined based on the methodology presented in Reference 4. The ring settings themselves were not provided. Provide the settings for the upper, middle, and lower rings in the Catawba valves for review. These settings should be provided relative to the level position to be consistent with the method used to report the ring positions in the EPRI tests. Provide additional information to show how the method in Reference 4 was used to determine expected valve performance such as percent of rated flow and lift, blowdown, and valve stability under the steam, steam/water transition, and water flow conditions expected at the plant.

RESPONSE: The ring settings for Catawba are:

Upper: -48 notches from top of vent port
Middle: -67 notches from seat plane
Lower: +10 notches from seat plane

As stated, the Catawba ring settings were developed using the ASME paper "A Correlation for Safety Valve Blowdown and Ring Settings." The Catawba valve, model 31749A, was not tested by EPRI, so direct ring settings were not available. The correlation paper allows ring settings to be developed based on the test experience gained from the 31739A and 31709NA valves.

The primary considerations in developing ring settings were to attain stable performance and full flow. Relatively strong ring settings, i.e., middle and lower ring closer together, tend to provide that performance. The consequence is longer blowdowns. Ring settings that gave a blowdown of approximately 12% were chosen. Blowdowns in this range gave stable performance and full lift for the 31739A valve with high backpressures and with a long inlet pipe.

The Catawba Overpressure Protection Report was revised to reflect the use of the increased blowdowns.

QUESTION 6.

The information in References 1 and 2 did not provide the maximum bending moment calculated to occur at the outlets of the safety valves and PORVs at Catawba 1 & 2. Compare the worst case, plant calculated values to those applied to the valves in the EPRI tests. The calculated bending moments should include the effects of deadweight, thermal expansion, earthquake (SSE), and valve actuation loads. If the bending moments for the plant valves exceed those applied to the test valve, justify that the plant valves will operate satisfactorily with the higher bending moment.

RESPONSE: Unit 1

SAFETY VALVES: (Dresser 31749A)

COMPARISON OF C-E TEST VALVE MOMENTS TO PLANT SPECIFIC ANALYSIS

	EPRI TEST	ANALYSIS
	Lateral Moment (in-lbs)	Maximum Lateral Moment (in-lbs)
Test Number:	1011	
Valve Outlet:	241,738	143,951

POWER OPERATED RELIEF VALVES

1. Control Components

	EPRI TEST	ANALYSIS
	Lateral Moment (in-lbs)	Maximum Lateral Moment (in-lbs)
Test Number:	47-CC-3S	
Valve Outlet:	39,000	27,440

Unit 2

SAFETY VALVES: (Dresser 31749A)

COMPARISON OF C-E TEST VALVE MOMENTS TO PLANT SPECIFIC ANALYSIS

	EPRI TEST Lateral Moment (in-lbs)	ANALYSIS Maximum Lateral Moment (in-lbs)
Test Number:	1011	
Valve Outlet:	241,738	134,813

POWER OPERATED RELIEF VALVES

1. Control Components

	EPRI TEST Lateral Moment (in-lbs)	ANALYSIS Maximum Lateral Moment (in-lbs)
Test Number:	47-CC-3S	
Valve Outlet:	39,000	34,288

NOTES:

(1) Moments are perpendicular to the plane of pipe configuration.

(2) Maximum lateral moment is the vectorial resultant of the two orthogonal moments. Load combination is gravity + thermal + blowdown.

(3) SSE loads are qualified in the original analysis and are not considered here because the blowdown loading is highly localized and has a very short duration. The probability of peak seismic loads occurring simultaneously with peak blowdown loads is extremely small. Also, a seismic event does not initiate an event resulting in safety valve discharge.

QUESTION 7. PORV Block Valves

a. The EPRI/Marshall block valve tests were performed with THE valves in a horizontal position (valve stem vertical). The Rockwell block valves at Catawba 1&2 are designed for use in a horizontal orientation only. Identify the orientation of the Catawba block valves. If other than horizontal, provide detailed information on how the EPRI data was extrapolated to assure operability in the plant specific orientation.

b. The PORV block valve tests performed by EPRI used only full pressure, full flow steam inlet conditions. The block valves at Catawba may need to operate under steam, steam/water transition, and water discharge conditions. Review of the EPRI test data and operation of gate valves, such as the Rockwell valves used at Catawba 1&2, indicated the steam tests were sufficient to show block valve operability under all operating conditions. However, the reasons for accepting sufficiency of the steam tests were based in part on testing done by Westinghouse on stellite specimens. These tests indicated the friction coefficient for the stellite specimens was about the same in either steam or water. Clarify whether the Rockwell valves at Catawba 1&2 have a stellite coated disk and seat. If the Rockwell valves have other than stellite coated disks and seats, discuss why the block valve steam tests are sufficient to show block valve operability under all expected inlet conditions.

RESPONSE:

a. The Catawba Valves are installed in a horizontal line with stems vertical.

b. The Rockwell valves have Stellite #21 hardfaced disks, seats, and valve guides.

QUESTION 9. Thermal Hydraulic Analysis

a. The adequacy of the thermal-hydraulic analysis could not be verified since it was not presented in the submittal. Identify the computer program used for the analysis and provide verification of the thermal-hydraulic analysis program and post processor, if any, used in conjunction with the thermal-hydraulic analysis program to compute the fluid forces. The verification effort should include comparisons to EPRI/CE data or another benchmarked code.

RESPONSE: **THERMAL-HYDRAULIC ANALYSIS CODES**

a. The thermal-hydraulic analysis for the Catawba SRV qualification was performed using RELAP5/MOD1 CYCLE 14. Air/Water updates were added to cycle 14 as recommended by an interim EPRI/Intermountain Technologies report on the application of RELAP5 to SRV hydro-dynamic loads. The final report, EPRI NP-2479, "Application of RELAP5/MOD1 for Calculation of Safety and Relief Valve Discharge Piping Hydrodynamic Loads" was released in December of 1982. The EPRI report confirmed the applicability of RELAP5/MOD1 for the analysis of pressurizer relief line discharge loads.

In the EPRI study, RELAP5 control components were developed to convert the hydrodynamic transient data into a force-time history format suitable for input into the structural analysis computer code. In a parallel effort, EPRI had commissioned Impell (then EDS Nuclear) to develop a post-processor for RELAP5/MOD1 which would produce force-time histories in a general format suitable for input into structural analysis codes such as Impell's SUPERPIPE code. This post-processor was called REFORC (Ref. Impell Report No. 01-0650-1194, Rev. 1, "REFORC - Computer Program for Calculating Fluid Forces," based on RELAP5 Results, June, 1982). REFORC is now an approved EPRI code, and has become the standard post-processor for problems of this type. REFORC has been verified in accordance with Impell's quality assurance procedures, and has been benchmarked against sample standard fluid discharge problems.

QUESTION 9. b. Identify parameters such as timestep, valve flow area, valve opening time, valve opening pressure, pressure ramp rate, peak pressure, choked flow location, and node spacing and discuss the rationale for their selection. Provide evidence to show that with the parameters used bounding forces were calculated, i.e., piping forces were not underestimated due to numerical smearing because of the nodalization or time step size used.

RESPONSE: **RELAP5 ANALYSIS PARAMETERS**

b. The Catawba RELAP5 analysis is consistent with the recommendations stated in Section 5 of EPRI Report Np-2479, "Application of RELAP5/MOD1 for Calculation of Safety and Relief Valve Discharge Piping Hydrodynamic Loads." Specific details in regard to key analysis parameters follow:

Timestep Selection

The RELAP5 timestep was allowed to vary between $1x10^{-7}$ and $1x10^{-3}$ seconds. The code selects the largest timestep within the specified range which satisfies the computational error limits. The timestep is automatically reduced when required to maintain accuracy. The RELAP5 output was carefully examined to ensure that no timestep related instabilities had developed which might compromise the analysis results.

Control Volume Sizing and Locations

Numerical smearing can occur when the combination of timestep/control volume size is too large to mathematically track the fluid velocities and/or pressure wave front velocities generated during the SRV discharge transient. To preclude smearing and instabilities, control volume lengths in sensitive pipe areas (SRV/PORV inlet and outlet piping) were limited to lengths between

0.5 - 1.0 feet. Care was taken to avoid linking small pipe volumes with large volumes. In EPRI report NP-2479, a nodal sensitivity study was performed which determined that node lengths in the range of 0.5 to 1.0 feet produced acceptable force results for piping in the vicinity of the SRV's.

Valve Opening Times

EPRI Report NP-2628-SR gives data on SRV and PORV actual test performance. The report contains information on opening times for Dresser valves 31739A and 31709NA, the former slightly smaller than the Catawba SRV's and the latter slightly larger. Tests were performed at various steam pressures. The smallest observed opening "pop" time for both valves which occurred more than once per test was 0.015 seconds. Therefore, the SRV lift time for the analysis was set at 0.015 seconds.

For the PORV's the EPRI report gave a minimum opening time for the Control Components (CCI) relief valves equal to 1.6 seconds for steam conditions. The opening rate used in the Catawba analysis corresponds to a PORV opening stroke time of 1.5 seconds, which is slightly conservative.

Valve Opening Pressure, Ramp Rates, and Peak Pressure

Table 5-1 in EPRI Report MP-2296 ("Valve Inlet Fluid Conditions for Pressurizer Safety and Relief Valves in Westinghouse Designed Plants") gives the maximum rate of pressure increase for the reference 4-loop Westinghouse plant when SRV's only (no PORV's) are used. The maximum rate is 144 psi/sec for the Locked Rotor transient. When PORV's and SRV's are used, the maximum rate is 130 psi/sec for the Load Rejection transient. The Catawba analysis used the most conservative 144 psi/sec rate. The SRV opening setpoint pressure was 2500 psia. Pressurizer pressure was ramped up from 2500 psia at 0.0 seconds to a maximum of 2575 psia at 0.5208 seconds, corresponding to a ramp rate of 144 psi/sec. Table 5-1 of the EPRI report also lists a maximum pressurizer pressure of 2455 psia for the reference 4-loop plant. Thus, the peak pressure of 2575 psia used in the Catawba analysis is conservative and bounds the EPRI/Westinghouse data.

Choked Flow Locations

The use of the RELAP5 choking algorithm was limited to the actual SRV/PORV junctions, and the junctions in the first pipe segment immediately downstream of the SRV's. All other junctions were unchoked for both the steam discharge and water discharge analyses. The use of unchoked flow calculations is consistent with the recommendations of EPRI report NP-2479.

Valve Flow Areas

For the SRV's the valve area was adjusted to achieve the desired flow rate of 526,192 lb/hr steam at 2485 psig. This is the actual maximum flow rate documented in a letter from Dresser's Mr. J. S. Danielson to DPC's Mr. V. H. Shellhorse, dated May 12, 1982. This value is 21% higher than the rated SRV flow. A series of RELAP5 runs were made with steam at 2500 psia until the user specified flow area convergea on the target flow rate. The RELAP5 abrupt area change option was used for the PORV's and SRV's.

Per EPRI report NP-2296, "Valve Inlet Fluid Conditions for Pressurizer Safety and Relief Valves in Westinghouse Designed Plant", the rated flow of the CCI PORV is 210,000 lb/hr steam at 2350 psia. The Catawba analysis used a conservative flow rate of 232,000 lb/hr, an increase of 10.5% over rated flow. The PORV flow area was calculated using the Moody choking model. The area can be determined directly from the Moody choked flow tables if the mass flow, setpoint pressure and stagnation enthalpy are known. For steam flow, the resultant PORV flow area was calculated to be 0.011 ft^2. This value was used in the analysis.

QUESTION 9. c. Discuss the valve opening sequences analyzed. In a typical safety valve and PORV discharge analysis, the piping loads are calculated by assuming two discharge conditions. The first simulating the PORV discharge and the second simulating the (PORV inoperable) safety valve discharge condition. In the first case, both PORVs are assumed to actuate with the safety valves closed. In the second case, all safety valves are assumed to actuate while the PORVs remain closed. Such an analysis would bound all valve discharge modes including the simultaneous actuation of all safety valves and PORVs. If other discharge conditions were used, provide justification to demonstrate that the piping discharge forces calculated by these cases envelope the separate discharge of the safety valves and PORVs suggested above.

RESPONSE: **Valve Opening Sequences**

c. For both the steam discharge and water discharge analyses, the SRVs and PORVs were opened simultaneously. Since the SRV opening time is much faster than the PORV opening stroke time (0.015 seconds versus 1.5 seconds), opening the valves simultaneously will have little effect on the SRV discharge loads. The peak loads due to SRV discharge occur prior to full PORV opening.

The primary reason for performing the SRV and PORV blowdown analyses independently is to prevent backpressure in the common discharge piping from reducing the maximum calculated discharge loads. Backpressure in the system due to earlier SRV opening can reduce PORV discharge loads, an vice-versa. So today, most SRV/PORV analyses are decoupled to ensure maximum conservatism unless there are unusual circumstances which would make a coupled analysis more conservative.

However, in 1982 it was thought that a simultaneous discharge of all valves using maximum flow rates would create the highest structural loads on the entire pressurizer relief system, thereby making the simultaneous blowdown event the most conservative case. The 1982 CATAWBA analysis opened all valves simultaneously for both the steam discharge and water discharge (extended HPI) analyses.

QUESTION 9: d. Identify the initial conditions for the safety and relief valve thermal-hydraulic analyses. Because the ASME Code requires derating of the safety valves to 90% of actual flow capacity, the safety valve analysis should be based on a flow rating equal to 111% of the flow rate stamped on the valve, unless another flow rate can be justified. Provide further information explaining how derating of the safety valves was handled and describing methods used to establish flow rates for the safety valves and PORVs in the thermal hydraulic analyses.

RESPONSE: **Initial Conditions and Flow Rates**

d. As noted earlier in the discussion of valve opening pressure (9.b.), the bounding initial conditions for transients which challenge the SRVs and PORVs are listed in EPRI/Westinghouse Report NP-2296. The maximum Pressurizer pressures for Steam discharge are 2555 psia saturated steam, with SRV opening at 2500 psia, and a ramp rate of 1444 psi/sec. The CATAWBA steam discharge analysis bounds these parameters by utilizing a peak pressure of 2575 psia combined with a 144 psi/sec. ramp rate. The CATAWBA SRVs are opened at t = 0.0 sec (2500 psia).

For transients which challenge both the safety and relief valves, the EPRI report lists a PORV opening setpoint of 2350 psia, a peak pressure at 2532 psia, and a ramp rate of 13 psi/sec. The CATAWBA analysis bounds these parameters by applying the SRV initial conditions (2500 psia, 2575, psia peak, and 144 psi/sec. ramp rate) to the PORVs.

The EPRI report lists the following maximum valve inlet conditions for the spurious HPI event:

Peak pressurizer pressure = 2507 psia
Maximum pressure ramp rate = 4 psi/sec.
Valve inlet fluid temperature = 565-572 F

The CATAWBA extended HPI analysis used the same initial conditions and pressure ramp rates as the steam analysis, except that the pressurizer and SRV/PORV inlet lines were initialized with 498 F subcooled water at 2500 psia. The lower fluid temperature and higher pressures completely bound the EPRI/Westinghouse valve inlet conditions for the 4-loop reference plant.

SRV/PORV Flow Rates

The earlier discussion of SRV flow rates in response to question 9.b (valve flow areas) explained how the valve areas were sized so that the flow rate used in the analysis would exceed the name plate rated flow by 21%. The actual steam flow rate of 608,000 lb/hr achieved in the analysis exceeded the target flow by 15.5%. The total increase over the rated flow of 434,789 lb/hr was 40%. Thus the CATAWBA SRV steam flowrate analysis is highly conservative. The response to question 9.b (valve flow areas) also describes how the flow area for the PORVs was adjusted to achieve the target maximum flow rate of 232,000 lb/hr, a 10.5% increase over rated flow. The analysis results show that at 50% stroke, the PORV steam flow = 133,200 lb/hr, corresponding to a VWO flow rate of 266,400 lb/hr, a 27% increase over the rated flow rate (RELAP5 incorporates a liner stroke vs area relationship for valves). In conclusion, steam flowrates used in the CATAWBA analysis are highly conservative.

For water flow through the SRVs and PORVs (extended HPI event), Duke provided operating modes for the transient as an attachment to DPC letter CN-SA-82-0926, dated 5-12-82. The op modes defined flow rates in the 12" common header for the extended HPI event with and without PORV operation. Consistent with the supplied op modes, each SRV and PORV was sized so as to relieve 100% of the common header flow. The SRV flow areas were adjusted to achieve a target liquid flow of 255,799 lb/hr, and the PORV flow areas were adjusted for 396,792 lb/hr liquid flow. The valve flow areas were adjusted in successible RELAPs runs until the desired flows were achieved. The final flow areas for liquid flow were 0.0021 ft^2 for the PORVs. Since all valves were assumed to open simultaneously, the combined flow rates in the common headers were highly conservative.

QUESTION 9: e. Provide a copy of the thermal-hydraulic analysis report.

RESPONSE: e. No formal thermal-hydraulic report was prepared for Catawba. The analysis (CNC-1206.02-54-0024) is on file and available in the Design Engineering General Office.