REGULATORY INFORMATION DISTRIBUTION SYSTEM (RIDS)

ACCESSION NBR: 8801280210 DOC. DATE: 88/01/15 NOTARIZED: NO DOCKET #

FACIL: 50-269	Oconee Nuclear Station, Unit 1, Duke Power Co.	05000269
50-270	Oconee Nuclear Station, Unit 2, Duke Power Co.	05000270
50-287	Oconee Nuclear Station, Unit 3, Duke Power Co.	05000287

AUTH. NAME	AUTHOR AFFILIATION
TUCKER, H. B.	Duke Power Co.
RECIP. NAME	RECIPIENT AFFILIATION
	Document Control Branch (Document Control Desk)

SUBJECT: Forwards response to requests 5 through 12 of addl info re NUREG-0737 Item II. D. 1, "Performance Testing of Relief & Safety Valves."

DISTRIBUTION CODE: A046D COPIES RECEIVED: LTR 1 ENCL 1 SIZE: 20
TITLE: OR Submittal: TMI Action Plan Rqmt NUREG-0737 & NUREG-0660

NOTES: AEOD/Ornstein: 1cy.	05000269
AEOD/Ornstein: 1cy.	05000270
AEOD/Ornstein: 1cy.	05000287

	RECIPIENT ID CODE/NAME	COPIES LTTR	COPIES ENCL	RECIPIENT ID CODE/NAME	COPIES LTTR	COPIES ENCL
	PD2-3 LA	1	0	PD2-3 PD	5	5
	PASTIS, H	1	1			
INTERNAL:	AEOD/DOA	1	1	AEOD/DSP/TPAB	1	1
	ARM/DAF/LFMB	1	0	NRR/DEST/ADE	1	0
	NRR/DEST/ADS	1	0	NRR/DEST/MEB	1	1
	NRR/DREP/EPB	1	1	NRR/DREP/RPB	1	1
	NRR/PMAS/ILRB	1	1	OGC/HDS2	1	0
	~~REG FILE~~ 01	1	1	RES/DE/EIB	1	1
	RES/DRPS DIR	1	1			
EXTERNAL:	LPDR	1	1	NRC PDR	1	1
	NSIC	1	1			
NOTES:		1	1			

TOTAL NUMBER OF COPIES REQUIRED: LTTR 24 ENCL 19

DUKE POWER COMPANY
P.O. BOX 33189
CHARLOTTE, N.C. 28242

HAL B. TUCKER
VICE PRESIDENT
NUCLEAR PRODUCTION

TELEPHONE
(704) 373-4531

January 15, 1988

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

Subject: Oconee Nuclear Station
Docket Nos. 50-269, -270, -287
"Performance Testing of Relief and Safety Valves"
Request for Additional Information

Dear Sir:

By letter dated April 22, 1987, the NRC requested additional information regarding NUREG-0737 Item II.D.1, "Performance testing of relief and safety valves", for Oconee Nuclear Station. By a letter dated August 6, 1987, Duke had provided a response to requests 2, 3 and 4, and had advised that the remaining responses would be provided by January 15, 1988. Accordingly, please find attached Duke's response to requests 5 through 12. For request 1, Duke anticipates in providing a response by February 10, 1988.

Very truly yours,

Hal B. Tucker/

Hal B. Tucker

PFG/1225/sbn

Attachment

xc: Dr. J. Nelson Grace, Regional Administrator
U. S. Nuclear Regulatory Commission
Region II
101 Marietta Street, NW, Suite 2900
Atlanta, Georgia 30323

Mr. P. H. Skinner
NRC Resident Inspector
Oconee Nuclear Station

Ms. Helen Pastis
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

A046
/1

DUKE POWER COMPANY
OCONEE NUCLEAR STATION

ATTACHMENT

NUREG-0737 ITEM II.D.1

"PERFORMANCE TESTING OF RELIEF AND SAFETY VALVES"
RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION
(5 THROUGH 12)

REQUEST 5:

In the RELAP5 thermal-hydraulic analysis used by the licensee to evaluate the safety valve and PORV piping and supports, the main control parameter was the flowrate through the pressurizer surge line. Peak pressure and pressurization rate were not controlled to specified values but were calculated as the consequence of the insurge rate. The licensee did not provide values for these two parameters. The licensee should provide values evaluated for the peak pressure and pressurization rate. If less than the peak pressure of 2677 psia and pressurization rate of 175 psi/sec. identified in the B&W inlet conditions report, then justify the results of the thermal-hydraulic analysis are still valid.

RESPONSE 5:

Analysis results showed a peak pressure of 2515 psig at the inlet to the safety relief valve. Also, the average pressurization rate was determined to be approximately 100 psi/sec. From the B&W report: "Valve Inlet Fluid Conditions for Pressurizer Safety and Relief Valves for B&W 177-FA and 205-FA Plants, NP-2325-LD Research Project V102-17, Interim Report April 1982," the most conservative values for the pressurization rate and peak pressurizer pressure appear on page 4-11 in Table 4-11 for the accident condition "Rod ejection at HZP." For this generic accident, a peak pressurizer pressure of 2677 psia and a pressurization rate of 175 psi/sec. was determined using FSAR analysis techniques. In developing a design basis for the pressurizer safety valve piping, this severe transient, which involves a LOCA as well as a reactivity addition accident, was considered to be of such low probability that it was unnecessarily conservative. We considered that the integrity of the pressurizer safety valve discharge piping would be of little concern to a plant faced with a rod ejection accident. Accordingly, a less severe reactivity addition accident with a more reasonable probability of occurrence was selected for the design basis.

The conditions used by the licensee in the RELAP5 thermal-hydraulic analysis were based on information contained in Sections 15.1 and 15.2 of the "Duke Power Company Oconee Nuclear Station Final Safety Analysis Report Volume 8." On page 15.2-3, it is stated that none of the postulated startup accidents, except for reactivity addition rates greater than 2x10 (k/k)/sec. which is three times greater than withdrawal of all rods at once, causes a thermal power peak in excess of 100 percent rated power or a nominal fuel rod average temperature greater than 1150F. The nominal 1.5 percent k/k rod group withdrawal during startup causes a peak pressurizer pressure of 2515 psia, the code safety valve setpoint. The report concludes that the reactor is

completely protected against any startup accident involving the withdrawal of any or all control rods since in no case does the thermal power approach 112 percent and the peak pressure never exceeds code allowable limits.

REQUEST 6A:

The following additional information on the thermal-hydraulic analysis used to evaluate the piping and support system is requested. The mass flowrate used for the safety valve was 18% higher than the rated flow. Tests with the Dresser 31739A safety valve showed flows in excess of 122% of rated. Justify the flowrate used in the analysis is appropriate. Also, the Dresser 31739A rated flow of 82.7 lb/sec discussed in your response to Question 16 was based on Rev. 1 of the EPRI Guide for Application of Valve Test Program Results to Plant-Specific Evaluations. Rev. 2 of the same guide lists the Dresser 31739A rated flow as 89.7 lbm/sec. Identify the value for rated flow which is correct for the Dresser valves at Oconee 1, 2, and 3.

RESPONSE 6A:

From the manufacturer's drawing of the pressurizer safety valve, the steam flowrate at 10% accumulation is 317973 lbm/hr or approximately 88 lbm/sec. The actual flow rate used in our analysis has been found to be 109 lbm/sec or 123% of rated.

REQUEST 6B:

The response stated piping segments were selected to be two feet long or less. Provide more information on the model nodalization including details on both node size and location. This is needed for review since forces can be underestimated by inappropriate nodalization.

RESPONSE 6B:

The safety relief valve system model consisted of ten pipe volumes, two branch volumes, four single junctions, four motor valves, one time dependent junction and one time dependent volume. The pressurizer was modelled as a pipe volume having the pressurizer geometry. Valve inlets and outlets were modelled as pipe subvolumes having the same area and orientation as the valve inlets and outlets. The valve throats were modelled as junctions using areas from manufacturer's specifications. The pipes were divided into subvolumes of approximately two foot lengths to avoid violation the Courant limit with the minimum time step. Pipe fitting losses were added at junctions. The quench tank was modelled as a time dependent volume maintaining a constant 30 psia. A time dependent junction was used to model the insurge into the pressurizer. The junction was

attached to the lower end of the pressurizer. Junctions were defined at locations of geometric change such as orifices, nozzles and valves. In order to properly model gravity head, system elevations were preserved by defining junctions at minimum and maximum elevations. Junctions were used so that at least one control volume would be located between each bend to obtain
fluid reaction forces on piping.

The nodalization for the thermal/hydraulic analysis was based on the guidance given in the manual for the REPIPE computer code:

Control Data Corporation: *REPIPE Application Reference Manual*, Rev. B, March, 1982

The manner in which this nodalization was done is described in great detail in our response to Question 7.

REQUEST 6C:

The response to our request for information did not provide the safety valve opening time used in the analysis. Provide this information.

RESPONSE 6C:

The safety valves were modelled as RELAP5 motor valves with an opening time of 15 msec.

REQUEST 6D:

Duke's response to Question 16 of our request for information stated the PORV flowrate used in the analysis was 30 lbm/sec for steam flow and 70 lbm/sec for water flow. The response did not discuss how this compared to the PORV rated flow because it was stated that the long stroke time of the PORV precluded development of significant PORV discharge pipe forces. In part (c) of Duke's response, however, it was stated that PORV opening time of 15 milliseconds was used. This opening time is comparable to the measured opening time of the safety valves and appears to be in error. Please provide the correct opening time used in the analysis. Compare the PORV flowrate for water and steam to both the rated flow and the experimentally measured flows in the EPRI tests.

RESPONSE 6D:

The correct opening time of the PORV used in the analysis was 50 msec. Even though this is fast, the slower opening time and lower flow rate compared to the safety valve made the safety valve opening transient limiting. The PORV has a rated steam flowrate of 30 lbm/sec and a rated water

flowrate of 70 lbm/sec. From the EPRI tests, the steam and water flowrates were approximately 35 lbm/sec and 84 lbm/sec, respectively.

REQUEST 7:

Discuss how REPIPE calculates piping forces from RELAP5 output and provide results of verification calculations for EPRI/CE tests for our review.

RESPONSE 7:

The input to REPIPE comes from a program capable of analyzing the hydrodynamic transient behavior of piping networks. This program, RELAP5, was developed at the Idaho National Engineering Laboratory (INEL) for the purpose of analyzing nuclear reactor loss-of-coolant accidents. The RELAP5 computer program describes a piping network by dividing the system into a series of calculational units called control volumes. The control volumes are connected by flow paths called junctions. Hardware and components are placed at control volumes (e.g., pumps) or junctions (e.g., valves and leaks). It is within each of the control volumes that the transient forces processed by REPIPE are generated. Refer to Figure 1.

The general behavior of transient fluid flow is relatively well known. The only ways fluid can exert force upon its container are:

fluid pressure (p) acting normal to the wetted surface
fluid friction (τ) acting tangent to the wetted surface.

The stresses in the container depend on both the magnitude and distribution of p and τ on the location of support reactions. However, in most piping problems, the critical stresses are not so much influenced by the instantaneous pressure and drag at the particular location as by the collective effect (resultant) of these wetted surface forces and the bending moments they induce as the pipe reacts and supports the moving fluid. The pipe stress analyst is concerned with a three-dimensional network of one-dimensional "beams," loaded by the net imbalance of the hydrodynamic forces. Thus the distributed normal pressure and surface tractions are replaced by concentrated loads acting at convenient node points in the structural network.

At the same time, these wetted surface forces act on the fluid and, by definition, change its momentum. In looking at this change of momentum, we consider a control volume of fluid bounded by the wetted surface of its physical container (the pipe) and one or more inlet/outlets. For such system the rate of change of momentum is given by:

$$\frac{\partial}{\partial t}\int_V \vec{u}\rho\, dV + \int_{S_o} \vec{u}_o (\rho_o \vec{u}_o \cdot \vec{n}_o)\, dS_o - \int_{S_i} \vec{u}_i (\rho_i \vec{u}_i \cdot \vec{n}_i)\, dS_i \qquad (1)$$

where:

V = control volume

$\vec{u}$ = local fluid velocity

ρ = mass density of fluid

S = control volume surface

o = subscript for outlet

$\vec{n}$ = unit vector normal to S

i = subscript for inlet

The volume integral is the mass acceleration within the control volume. Its contribution to the total force that acts on the container is commonly called the "wave force." The two "S" integrals represent forces of the container wall on the fluid surface. The sign on the S_i integral is positive in texts on fluid dynamics because in the general derivation, S has arbitrary orientation, the direction (and magnitude) of $\vec{u}$ can change over the surface, and $\vec{n}$ is defined as an outward normal. Here, we "anticipate" the application and take n in the assumed direction of positive flow (inward at an inlet) and take S_i and S_o perpendicular to $\vec{n}$. There is no loss of generality since we have not required $\vec{u}$ to be a constant over any one S.

In addition to the wetted surface forces acting on the control volume, two other force systems act on the control volume. One is the pressure of adjacent fluid:

$$\int_{S_i} p_i \vec{n}_i\, dS_i - \int_{S_o} p_o \vec{n}_o\, dS_o \qquad (2)$$

where:

p = fluid pressure (gauge) acting over S

The other force system is the force of gravity:

$$\int_V \rho \vec{g}\, dV \tag{3}$$

where:

$\vec{g}$ = acceleration due to gravity

To be rigorous, the surface integrals should be carried out over the entire control volume surface, but the momentum flux is identically zero in the normal direction along the solid (wetted) surface and the integral of the ambient pressure over the entire surface is identically zero. Thus, the surface integrals reduce to integrals over the inlet/outlet areas with p equal to gauge pressure. The force balance on the control volume is:

- (wetted surface force) + (adjacent fluid pressure)

+ (gravity) = (rate of change of momentum)

Further subdivision of the wetted surface force is not needed, since it is the collective effect of the wetted surface force that acts on the pipe and its negative that acts on the fluid. Thus, the total pipe reaction force (F_m) in the direction m is:

$$F_m = -\frac{\partial}{\partial t}\int_V \vec{u}\cdot\vec{m}\,\rho\, dV + \int_V \rho\vec{g}\cdot\vec{m}\, dV \tag{4}$$

$$- \int_{S_o}\left[p_o\vec{n}_o + \vec{u}_o(\rho_o\vec{u}_o\cdot\vec{n}_o)\right]\cdot\vec{m}\, dS_o + \int_{S_i}\left[p_i\vec{n}_i + \vec{u}_i(\rho_i\vec{u}_i\cdot\vec{n}_i)\right]\cdot\vec{m}\, dS_i$$

where:

F_m = total force acting on pipe in direction $\vec{m}$

$\vec{m}$ = unit vector in the direction of interest

The piping network is described to RELAP5 as a set of connected control volumes. RELAP5 computes the fluid properties within these volumes and in the connecting flow junctions at discrete time points (steps). REPIPE combines this fluid state information with additional user-supplied piping geometry data to compute the resultant force on selected control volumes.

Pipe reaction force (F_m) is computed by REPIPE through the use of equation (5):

$$F_m = \sum (pa + \rho a v|v|)_i \vec{n}_i \cdot \vec{m} - \sum (pa + \rho a v|v|)_o \vec{n}_o \cdot \vec{m} - \vec{w} \cdot \vec{m} \quad (5)$$

where $\vec{w}$ = vector waveforce derived from RELAP5 output

The most straightforward way to develop the piping forces is to compute equation (5) for each control volume and then attach each F_m to a convenient node. However, the fluid dynamic forces tend to push the piping outwards at bends, not draw it inward, and a "blind" application of equation (5) ignores this. While we expect the magnitude of Fm to vary, it will, in general, also change direction with time when a control volume includes a bend. On the other hand, if the line of action is fixed, only a single time-history table is needed for any one node along with an appropriate direction vector. Also, it can be argued that if the fluid flow problem is one-dimensional (which is assumed by RELAP5), then the fluid cannot produce a direct transverse load on the pipe. Thus, piping stress analysts have generally applied the dynamic loads to nodes located at both ends of bends, and parallel to the connected pipe.

In order to conform to the modeling guidance given by the REPIPE code authors, each straight leg of piping was modeled with one or more straight control volumes that extended to the center of the bends at each end. This concept is illustrated in Figure 1. The turning of the fluid is assumed to occur in this mid-bend junction, not within a control volume. The pipe stress model does not have to include a node at the bend midpoint to match this resulting junction. In fact, the associated piping nodes were at either end of the bend where the forces can be input in line with the pipe.

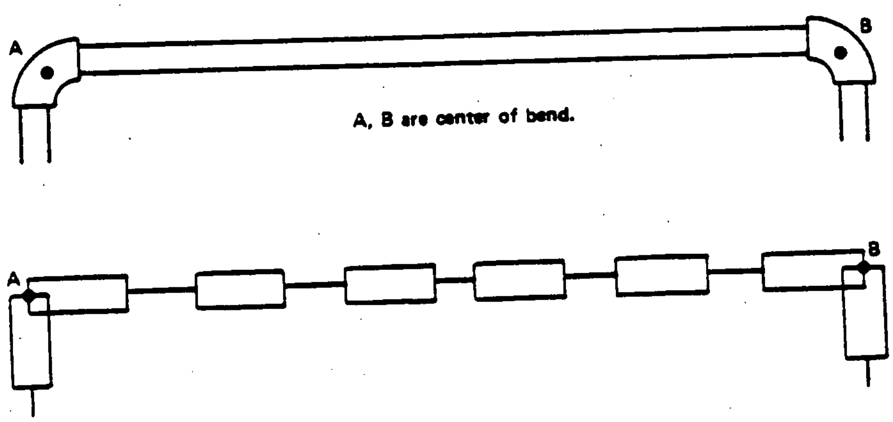

Figure 1. RELAP5 Model of Pipe with Bend

If several contiguous control volumes are in a single straight run of pipe and a single leg force reaction is computed for the run, it can be seen that the pressure and momentum flux terms at, say, the outlet of the first volume are the same as these terms at the inlet of volume two, etc. Only the combined wave force plus one inlet and one outlet for the entire leg remains. If the leg includes a right-angle bend at each end, only the wave force remains in the direction of the leg (see Figure 2). This concept of the "bounded leg" is discussed by F. J. Moody in his classical reference on piping stress caused by fluid flow. It can be readily extended to a large run of pipe with many bends (not necessarily right-angle bends) and even tees.

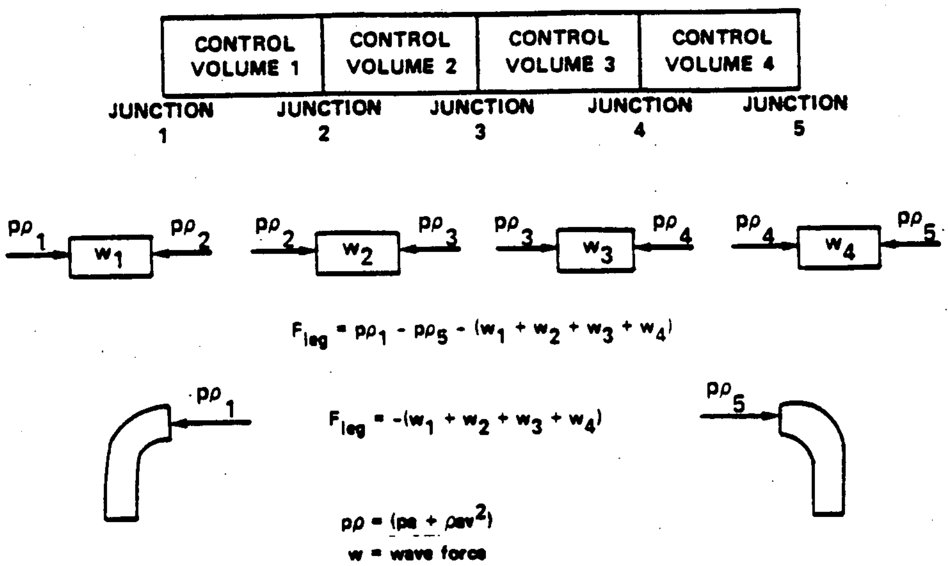

Figure 2. Computation of Forces in a Bounded Leg

REPIPE couples the RELAP5 model and the stress model via the "Item B set" in the code input. The Item B set defines the positive flow direction (n) at each junction, but it also is used to establish a "bookkeeping" relationship between the flow junctions and structural nodes. Since the force (equation 5) is associated with a control volume, one would expect to see nodes related to volumes. But our experience has shown that it is better to associate either the net force or the individual vectors that define net force (i.e., the right side members of equation 5) with the volume's junctions. In this way, REPIPE is able to change the nodal attachment of the force when the force direction changes. It also permits the final net node loads to remain parallel to the connected piping. This feature of REPIPE was used in our analysis.

Placing a turn in a junction as shown in Figure 1 presents no physical problem. In fact, the turning loss coefficients are input to RELAP5 at junctions. But equation (5) is applicable to a fluid volume, not a point or area (junction). This purely mathematical restriction is circumvented by assuming a massless "virtual volume" in the junction.

The virtual volumes contain no mass and their wave force is zero. Their pressure and momentum terms for equation (5) are readily obtained from the adjacent real control volumes of the RELAP5 model. The existence of virtual volumes allows REPIPE to correct the one-dimensional nature of RELAP5 and properly insert the forces occurring at the bends in the pipe network.

The REPIPE program was not verified by the EPRI/CE tests. Per conversation with Linda Goodwin in the Application Resource Center of Control Data Corporation, the program was verified by CDC with data to support the REPIPE program. At the time that our analysis was performed, Control Data Corporation and Cybernet Services were qualified vendors of computer services to Duke Power Company, and their code qualification program had been audited and found to meet Duke Power Company QA standards.

Request 8:

Provide more information on the verification of SUPERPIPE and comparisons of calculated results to EPRI/CE data for our review.

Response 8:

In Revision 2 of the "EPRI PWR Safety and Relief Valve Test Program Guide for Application of Valve Test Program Results to Plant-Specific Evaluations", Table II-4 titled "Workscope for Utility Evaluations of Piping/Support Adequacy", Item 2 is given as:

> "Using EPRI-provided code or other verified (by comparison with valve test results) method, evaluate stresses and support loads in inlet and discharge piping."

Also in this report, Table II-8 titled "Workscope for EPRI Evaluations," Item B is given as:

> "Provide verified computer code and valve program reports for utility evaluations of inlet and discharge piping and support adequacy. The code provided by EPRI is to be used for the calculation of the time-dependent hydraulic loads applied by the fluid on the piping."

Duke has used the code provided by EPRI, RELAP5, in the thermal hydraulic analysis. Since the Oconee forcing function results are based on the EPRI provided computer code, detailed "comparisons of calculated results to EPRI/CE data," as requested above, should not be a further requirement.

The forcing function results, as calculated by RELAP5 and REPIPE, are then loaded onto SUPERPIPE, a program for the structural analysis and code compliance evaluation of piping systems. SUPERPIPE analyzes the piping system for the effects of the forcing function by solving the equilibrium equations using step-by-step direct integration of the coupled equations of motion.

To the extent SUPERPIPE was used in this analysis it has been adequately verified as substantiated by our previous response. SUPERPIPE has been verified by bench-marking to an ASME sample problem, by comparison to detailed analysis performed manually and by comparison to results achieved using similar piping programs. The bench-mark problems specified in NUREG CR-1677 have been evaluated using SUPERPIPE and the results have been transmitted to the NRC.

Request 9:

Provide the following data on the structural analysis:

A. Integration time step used

B. Damping

C. Cutoff frequency. Based on EG&G Idaho, Inc. experience, most piping analysis should use a cutoff frequency of 100 Hz. If the cutoff frequency used is less than 100 Hz, provide assurance the use of a lower cutoff frequency does not invalidate the analysis performed.

Response 9:

A. The integration time step used was 0.001 seconds. Considering the time history of the forcing functions, .001 seconds is a sufficiently small time increment to capture an accurate total response.

B. For the direct integration method of a force-time history analysis, modal damping is assumed to vary with frequency as follows:

$$\lambda = \frac{\alpha}{4\pi f} + \beta\pi f$$

where f = modal frequency, and
λ = corresponding modal damping ratio

$$\alpha = \frac{4\ f_1 f_2 (f_{1\ 2} - f_{2\ 1})}{f_1^2 - f_2^2}$$

$$\beta = \frac{\lambda_1 f_1 - \lambda_2 f_2}{\pi (f_1^2 - f_2^2)}$$

For the subject analysis the following values were used:

f_1 = 10Hz, with, λ_1 = .005 = .5% of critical damping
f_2 = 20Hz, with, λ_2 = .005 = .5% of critical damping

C. The term "cutoff frequency" is not meaningful for a force time history analysis using the direct integration approach. A cutoff frequency is associated with a mode-by-mode (modal superposition) force time history analysis.

The Oconee analysis used the direct integration method. The direct integration method is preferred since the analysis is carried out directly on the coupled equations of dynamic equilibrium without uncoupling into normal modes; and hence, in principle, without truncating the high frequency effects.

Request 10:

Your response to Question 17(b) of our request for information identified the load combinations used in the structural analysis at Oconee 1, 2, and 3 but did not discuss the basis for these load combinations. Discuss the basis for the load combinations used in the structural analysis. Provide specific Code references as needed, citing addendum, articles, etc. Only one of the load combinations analyzed at Oconee 1, 2, and 3 included a valve discharge transient(UPS2), while those recommended by EPRI in the Guide for Application of Valve Test Program Results to Plant-Specific Evaluations included a valve discharge transient in all load combinations except Normal. It is the staff position that all load combinations except Normal include a valve discharge. Add the appropriate valve discharge transient to the Oconee load combinations or analyze load combinations similar to those recommended by EPRI and provide the results for our review. The Faulted Load condition used 2 X OBE instead of a SSE. What is the relationship between the earthquake design spectrum of the SSE and OBE. If SSE/OBE $\leq$ 2.0, using SSE = 2 X OBE is conservative. If SSE/OBE $\geq$ 2.0, justify use of 2 X OBE instead of SSE.

Response 10:

A. Basis for load combinations -

The Codes of Record for Oconee piping analysis are:

USAS B31.7 (1968), June 1968 Addenda; for Class 1 piping; and
USAS B31.1 (1967) for Class 2 and 3 piping.

Neither of these codes provide guidance for load combinations. Later versions of the code are more specific as to who is responsible for defining load combinations. Some excerpts from Section III of the ASME Code are reproduced here:

NC-3112.3 (1974): The specific combinations and values of mechanical loads which must be considered in conjunction with the design pressure and design temperature shall be those identified in the Design Specifications and designated as the Design Mechanical Loads.

NC-3112.3 (1977, 1980), NB-3112.3(1980): The specified Design Mechanical Loads shall be established in accordance with NCA-2142.1(c). They shall be used in conjunction with the Design Pressure.

NA-2142.1(c)(1977), NCA-2142.1(c)(1980): The specified Design Mechanical Loads shall be selected so that when combined with the effects of Design Pressure, they represent the most severe coincident loadings, for which the Level A Service Limits on primary stress are applicable.

NA-3252 (1977): The Design Specifications shall include...the design requirements including identification of component and support Design and Service Loadings and their combinations and associated Limits.

Response 10 (cont.):

NCA-2142.1(a)(1986): In the Design Specification, the Owner or his designee shall identify the loadings and combinations of loadings and establish the appropriate Design, Service and Test Limits for each component or support.

NCA-2150 (1980): The loading combinations...applicable to the design of components within a system, and the designation of the appropriate Design and Service Limits which may be used with each loading combination are beyond the scope of this Section.

From these excerpts, two points are made and more fully developed. One, the responsibility for specifying the load combinations lies with the Owner. And two, the effects of piping loads only require combination if the loads are coincident.

Load combinations are suggested in Appendix E of the July 1982 Report "EPRI PWR Safety and Relief Valve Test Program Guide for Application of Valve Test Program Results to Plant Specific Evaluations". Since the Oconee relief valves mount directly on the Pressurizer, Table 2A of this report is appropriate for discussion.

Valve discharge loads are included in Table 2A as three separate System Operating Transient (SOT) loads:

SOT_U = Relief Valve Discharge Transient or transition flow

SOT_E = Safety Valve Discharge Transient or transition flow

SOT_F = Max (SOT_U; SOT_E); or Transition Flow

The suggested load combinations include a case with Normal + PORV + OBE compared against Level C Service Limits. The safety valve discharge is combined with with Normal alone; and, the combination compared against Level C Service Limits. When maximum valve discharge is combined with earthquake the combination is compared to a Level D Service Limit.

The Oconee load combinations are different from the EPRI suggested combinations but not necessarily less conservative. The Oconee PORV discharge loads are relatively insignificant when compared to the safety valve discharge loads; and, for Oconee the maximum safety valve discharge loads are combined with Normal and compared against more restrictive Level B Service Limits instead of Level C as suggested in the EPRI report.

Response 10 (cont.):

Duke feels that the Oconee load combinations are fully adequate and just as reasonable. In accordance with the piping codes the load combinations are specified in the analysis specification. The Oconee analysis specification does provide for concurrent earthquake and steady state valve discharge loads. Steady state relief valve discharge forces are included in both the Upset and the Faulted conditions, concurrent with the OBE and the SSE respectively. Relief valve transient loadings are not specified concurrent with earthquake. A relief valve transient load lasting less than a second, such as the Oconee pressurizer PORV and safety valve discharge loads, should not be combined with other low probability events.

The only dependent relationship between an earthquake and a pressurizer relief valve discharge is to assume that the earthquake causes a loss of all feedwater which in turn causes primary pressure to rise and lifts the pressurizer relief valves. This is a design basis scenario. However, even in this unlikely event the time necessary to increase RCS pressure sufficient to require lifting of the PORV's is 250 seconds; and, approximately 270 seconds for the safety valves, in the worse case scenario. Since strong motion earthquakes typically last less than one minute, the earthquake loading will have ended by the time the valves lift. Thus, the dependent relationship between the earthquake and valve actuation does not result in coincident loading.

The only remaining scenario which could result in coincident loading is to consider the combination of these two events as independent quantities. However, as independent events the probability of simultaneous occurrence is statistically insignificant.

B. Relationship between OBE and SSE

Section 3.7.1.1 of the Oconee FSAR defines the MHE as two times the DBE. The FSAR uses the older terms "Design Base Earthquake (DBE)" and "Maximum Hypothetical Earthquake (MHE)" for the OBE and the SSE respectively. The latter terms, OBE and SSE, are current industry wide terms, also used by Duke. The original Oconee design basis included only one seismic event, the Design Base Earthquake. During, the licensing process the consequences of a larger earthquake were postulated. The MHE was defined as two times the DBE. Since the "SSE" equals "2 X OBE" for Oconee, the two terms are equivalent and interchangeable.

Request 11:

The allowable for the Faulted condition was defined as Sy @ $500^{o}F$ based on the USAS B31.7 (1969) Code. Review of this Code could not find the reference defining the allowable in this manner. Provide a more specific code reference (i.e., which addendum, article, etc.) defining this allowable stress.

Response 11:

The reference made to the USAS B31.7, 1969 Code was meant to provide the reference for the value of the material yield stress. The reference was not intended to mean that the USAS B31.7, 1969 Code provided for a faulted condition allowable of Sy.

The Code of Record for piping analysis at Oconee Nuclear Station is:

USAS B31.7 (1968) with June 1968 Addenda; for Class 1 piping; and,
USAS B31.1 (1967) for Class 2 and 3 piping.

The B31.7 Code is also used for those Class 2 and 3 piping material properties which are not included in the B31.1 Code. The USAS B31.1 (1967) Code does not contain material yield stress values.

Neither of these codes describe a faulted condition. Lacking definitive code guidance the original Oconee design was based on a faulted condition allowable stress of Sy, equal to the material yield stress at design temperature. This is very conservative compared to current code philosophy which has evolved as follows.

The first mention of faulted conditions in the piping code was in the 1971 edition of ASME Section III. Specifically, NB-3656.2 stated that "under any Faulted Conditions, Equation (9) of NB-3652 shall be met using a stress limit of 3.0 Sm". Note that 3.0 Sm equals two times the Design Condition allowable stress limit of 1.5 Sm.

Appendix F, titled "Rules for Evaluation of Faulted Conditions", was added with the Winter 1972 Addenda to ASME Section III. This appendix also stated that "when applying the procedures of NB-3652, Equation (9) should be satisfied using a stress limit of 3.0 Sm".

Paragraph NC-3655 was added with the Winter 1981 Addenda for the benefit of Class 2 piping. This paragraph states that: "For Service Loadings for which Level D Service Limits are designated, the conditions of Eq. (9) shall be met. The allowable stress to be used for this condition is 3.0 Sh but not greater than 2.0 Sy."

Response 11 (cont):

Paragraph NB-3656 was revised in part in the Winter 1981 Addenda specifying that the faulted condition allowable stress of 3.0 Sm should not exceed 2.0 Sy.

Clearly, the faulted condition allowable of 1.0 Sy established for the original Oconee design is very conservative in light of later code developments.

Request 12:

Pressurizer nozzle loads during safety valve and PORV discharge were not discussed. Compare the calculated and allowable loads for the pressurizer nozzle.

Response 12:

Allowable nozzle loads per se are not available. The nozzle evaluations consist of a comparison of the resultant calculated stress with the allowable stress. Stresses are tabulated in accordance with the methods and requirements of B&W's "Analysis of the 2-1/2" Pressure Relief Valve Nozzle". The calculation of primary membrane plus primary bending stress intensity, the loading condition which includes the valve transient discharge loads, produces the highest ratio of calculated to allowable stress. Only results for this loading condition are presented.

Stresses are tabulated at two locations on the nozzle; in the necked portion of least cross section; and, at the nozzle to shell juncture. Stress intensities due to nozzle reactions are simply calculated in the "neck", using straightforward classical methods. For the more complex geometry of "the nozzle to shell juncture" stress intensities due to nozzle reactions are calculated in accordance with Welding Research Council Bulletin Number 107.

Maximum(1) Calculated Loads(2) for Relief Valve Nozzles

Unit #	Axial Force (lbs)	Torsional Moment (ft-lbs)	Shear Force (lbs)	Bending Moment (ft-lbs)
1	23124	2810	6955	10657
2 & 3(3)	22781	2708	6901	10428

NOTES:

(1) Since the nozzle geometry of the safety valve nozzle is identical to the PORV nozzle, the loads for each unit have been enveloped to obtain a maximum loading. The three nozzles on any unit's pressurizer are then conservatively qualified with one evaluation.

(2) Calculated loads include the sustained loads during normal plant operation (gravity and thermal) plus maximum valve discharge transient loads.

(3) The Unit 2 and Unit 3 relief valve systems are essentially identical and are qualified by the same analysis.

Calculated Stress Intensities
vs.
Allowable Stress

Location Description	Calculated Stress (psi) (1)	(2)	Allowable Stress[3] (psi)
Unit 2 & 3 - "neck"	20059	21477	1.5 Sm =24750[4]
Unit 2 & 3 - "nozzle-to-shell juncture"	2319	14475	1.5 Sm = 26040[5]

NOTES:

(1) Calculated stress due to nozzle reactions only
(2) Calculated stress including pressure and bolt preload in addition to nozzle reactions
(3) Allowable stress = 1.5 Sm = the limit imposed on primary membrane plus primary bending stress intensity by the ASME Code Section III, 1965 with Summer 1967 Addenda, Nuclear Vessels.
(4) Neck constructed of SA-182 F316 material with Sm = 16.5 ksi at 670°F per ASME, Section III, 1965 with Summer 1967 Addenda.
(5) Nozzle-to-shell constructed of A-508, CL-1, material with Sm = 17.36 ksi at 670°F per code case 1332-4.
(6) Due to similarity in the relief valve nozzle loads the Unit 2 & 3 results are sufficient to qualify the Unit 1 nozzle as all other parameters are equivalent.