ATTACHMENT A

FLORIDA POWER CORPORATION
CRYSTAL RIVER UNIT 3

EARTHQUAKE INTENSITY FOR PIPING ANALYSIS AND PIPE SUPPORT DESIGN

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BACKGROUND

Two earthquake intensities are normally associated with the design of Nuclear Power Plants. These are the Operating Basis Earthquake (OBE) and the Safe Shutdown Earthquake (SSE). A nuclear power plant is expected to be designed so that a plant can continue to operate during an OE and to be safely shutdown in the event of a SSE. The ASME Boiler and Pressure Vessel (Section III, Subsections NA,NB,NC,ND,NE and NF) Code lists specific stress limits for pipe and supports for earthquake and other loadings. It is noted that the OBE stresses are restricted to lower allowables than the SSE stresses.

Many of the Crystal River Unit 3 Design and Analysis activities were conducted during 1970 to 1974. At that time the method of dealing with the two earthquake intensities was not as clear as it is today. The Crystal River Unit 3 FSAR attempted to provide guidance. For example, Section 5.2.1.2.9 "Earthquake Load" (A.tachment 1) states the position as concerns the Structural Design of the Reactor Building. This description is also applicable to the commitment for pipe support design and analysis. Basically this commitment is that the pipe and support stresses would be kept to within Code (USAS (ANSI) B31.1) Allowable Stresses. The factors of safety in the code allowables (Factor of Safety of 4) would then ensure that the pipe and pipe supports would not be impaired so as to present a safe and orderly shutdown of the plant in the event that the higher earthquake intensity would occur (SSE).

PIPE STRESSES

Section 5.4.4 of the FSAR (Attachment 2), "Piping Design Criteria" provides specific commitments in the area of piping design. Pages 5-64a and 5-64b state that the higher earthquake intensity (SSE or Maximum Hypothetical Earthquake (MHE) as known for Crystal River) is required to meet the USAS B31.1 Code. This is a more stringent commitment than that implied earlier in the FSAR (Attachment 1). This more stringent commitment on pipe stress was a voluntary step, taken to add more conservatism to the design.

LOADS ON PIPE SUPPORTS

Section 5.4.4 (Attachment 2) of the FSAR did not address the design loads on pipe supports. Two alternatives existed here. These were:

1) Use OBE loads to compare against USAS B31.1 or AISC allowables (consistent with philosophy expressed in Attachment 1).

2) Use MHE (or SSE) loads to compare against USAS B31.1 or AISC allowables (consistent with voluntary commitment on pipe stress).

Since no FSAR commitment on loads had been made, the first alternative was selected as a reasonable design basis. However, all pipe supports were checked against criteria "2" for record purposes. Approximately 95% of all seismic category I supports meet USAS B31.1 limits for the worst earthquake intensity (SSE or MHE) while 5% meet USAS B31.1 limits only for the lower earthquake (OBE).

It is predicted that maximum penetration depth for the worst probable missile is 6.2 inches against the exterior concrete wall thickness of safety related structures which is 24 in. minimum. As such, it is concluded that secondary missiles will not be generated within the structure which could damage the safety related equipment and systems.

In the Reactor Building, the personnel access, equipment access doors, and all penetrations are located inside Class I structures, which are designed for tornado generated missiles.

All access openings in Auxiliary, Intermediate, Diesel Generator, and Control Building are so located or protected by a missile shield so that no damage will be done to safety related equipment from tornado generated missiles.

5.2.1.2.7 External Pressure

The Reactor Building has been designed for an external atmospheric pressure of 2.5 psi greater than that of the internal pressure that could be caused by an accidental discharge from the spray system.

5.2.1.2.8 Operating Temperature

The normal operating temperature profile is shown in Figure 5-11. This profile was obtained from Reference 28, for a nuclear generating station located in Northern U.S.A., which has a more severe winter climate than Crystal River Unit 3. Thus the use of these profiles for Crystal River is considered to be conservative.

5.2.1.2.9 Earthquake Load

The site seismology and response spectra are described in Section 2.

The seismic design of the Reactor Building is based on the response to a ground acceleration as described below.

a. Primary steady state stresses, when combined with the seismic stress resulting from the response to a ground acceleration of 0.05g acting horizontally and 0.033g acting vertically and occurring simultaneously have been maintained within the allowable working stress limits accepted as good practice and, where applicable, set forth in the appropriate design standards, e.g: ASME Boiler and Pressure Vessel Code,(3) ACI 318-63(4), AISC Specification for the Design and Erection of Structural Steel for Buildings,(5) and USAS (ANSI) B31.1(6)

b. Primary steady state stress when combined with the seismic stress resulting from the response to a ground acceleration of 0.10g acting horizontally and 0.067g acting vertically and occurring simultaneously, has been limited so that the function of the structure is not impaired so as to prevent a safe and orderly shutdown of the plant.

The respective vertical and horizontal seismic components, at any point on the shell, have been added by summing the absolute values of the response (i.e., stress, shear, moment, or deflection) of each contributing frequency due to vertical motion to the corresponding absolute values of the response of each contributing frequency due to horizontal motion..

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FSAR

c. Diesel Generator Building

d. NSSW Intake Pump Structure

e. Intermediate Building

The tornado design requirements are as described in Section 5.2.1.2.6.

The structural design is in accordance with ACI 318-63, "Ultimate Strength Design."

5.4.3.2.3 Turbine Report

A vulnerability analysis of the plant design was made to determine what changes would have to be made in the event a turbine-missile could be produced. The basic criteria for this analysis was that plant shutdown and securement could not be jeopardized by a turbine-missile strike; moreover, the consequences of a strike could not cause or result in an uncontrolled release of excessive amounts of radioactivity. On this basis, those systems, structures, and components required to perform this function were reviewed, analyzed for vulnerability, and where necessary changes were made.

5.4.4 PIPING DESIGN CRITERIA

The piping design criteria for the primary loop is discussed in Section 4. The following design criteria covers the pipe lines not described in Section 4.

Nuclear class piping systems have been fabricated, erected, and inspected with the intent of satisfying the applicable sections of the CODE FOR NUCLEAR POWER PIPING USAS (ANS) B31.7.

The basic guideline for the design of piping has been the CODE FOR PRESSURE PIPING USAS (ANS) B31.1.0-1967 and those portions of CODE Case N7. Pertinent sections from this CODE apply to Class I piping described hereafter:

> CODE Para. 101.5.3 Earthquake
>
> "The effect of earthquakes, where applicable, shall be considered in the design of piping, piping supports, and restraints, using data for the site as a guide in assessing the forces involved. However, earthquakes need not be considered as acting concurrently with wind."

CODE Para. 101.5.4 Vibration

"Piping shall be arranged and supported with consideration of vibration."

CODE Para. 121.2.5 Sway Braces

"Sway braces or vibration dampeners shall be used to control the movement of piping due to vibration."

CODE Para. 102.3.2 (d) Additive Stresses

"The sum of the longitudinal stresses due to pressure, weight, and other sustained loads shall not exceed the allowable stress in the hot condition S_h. Where the sum of these stresses is less than S_h, the difference between S_h and this sum may be added to the term $0.25\ S_h$ in Formula (1) for determining the allowable stress range S_A."

$$S_A = f\ (1.25\ S_c + 0.25\ S_h) \qquad \text{(Formula 1)}$$

where S_c = Basic material allowable stress at minimum (cold) temperature from the Allowable Stress Table.

S_h = Basic material allowable stress at maximum (hot) temperature from the Allowable Stress Tables.

f = Stress range reduction factor for cyclic conditions for total number N of full temperature cycles over total number of years during which system is expected to be in operation.

The longitudinal pressure stress S_{1p} was determined by dividing the end force due to internal pressure by the cross-sectional area of the pipe wall:

$$S_{1p} = \frac{F}{A} = \frac{Pd^2}{(D^2 - d^2)}$$

where

S_{1p} = longitudinal pressure stress, psi

P = internal design pressure, psi

d = nominal inside dia of the pipe, in.

D = nominal outside dia of the pipe, in.

CODE Para. 102.3.3 Limits of Calculated Stresses Due to Occasional Loads

"The sum of the longitudinal stresses produced by internal pressure, live and dead loads and those produced by occasional loads such as the temporary supporting of extra weight may exceed the allowable stress values given in the Allowable Stress Tables by the amounts and durations of time given in Para. 102.2.4."

CODE Para. 102.2.4 Allowance for Variations from Normal Operation

"It is recognized that variations in pressure and temperature inevitably occur, and therefore the piping system shall be considered safe for occasional operation for short periods at higher than the design pressure or temperature.

Either pressure or temperature, or both, may exceed the design values if the stress in the pipe wall calculated by the formulas using the maximum expected pressure during the variation does not exceed the S-value allowable for the maximum expected temperature during the variation by more than the following allowances for the periods of duration indicated:

(1) Up to 15 percent increase above the S-value during 10 percent of the operating period.

(2) Up to 20 percent increase above the S-value during 1 percent of the operating period."

Major portions of Class I piping systems as herein described have been checked by thermal, dynamic (seismic), deadload, and pressure stress analysis. For those pipe lines designed in accordance with the seismic design criteria, dynamic analyses have been performed as herein described giving due attention to designed supports and restraints. Pipe lines operating at elevated temperatures have been analyzed for thermal expansion stresses. In addition, recognition has been given to stresses produced by internal pressure and the dead weight load of piping.

Class I piping 2-1/2" and larger (normally shop fabricated) along with piping system components including snubbers and dampers are analyzed by the Engineer and all supports, restraints and piping system components are shown and located on the drawings. Any changes in the field to the locations as shown on the drawings are to be made only after analysis and approval of the Engineer. Class I piping less than 2-1/2" (normally field run) is installed in the field in accordance to the maximum support and anchor criteria established by the Engineer. The maximum spacing varies with the line size and is determined for the most severe seismic loading for the plant location.

All piping two in. nominal pipe size and smaller is considered to be "field run," i.e., it is field fabricated from undimensioned isometric drawings prepared by the Engineer. The isometric drawing shows the approximate routing of the pipe.

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Typical pipe hanger sketches for these piping assemblies will be reviewed and approved by the Engineer for application and loading requirements prior to the sketches being issued for fabrication. Significant variation in routing is not usually possible, as the piping must pass through wall and partition sleeves which are located and uniquely designated by the Engineer.

Our mechanical contractor will make "Field Fabrication Sheets" for these pipe assemblies, which will specify the following:

a. A list of required materials, together with heat numbers
b. The detail sketch of how to fabricate the assembly
c. The welding instructions
d. The welding record
e. The NDT and visual inspection records
f. The quality control inspections and sign-offs

This will all be in strict accordance with approved Field Work and Quality Control Procedures. This field fabrication sheet will then be issued to the field fabrication shop for fabrication of the assembly. All field required quality control measures will be rigidly adhered to during this entire process. After installation of these assemblies, an inspector will "walk out" the particular assembly and then sign the associated field fabrication sheet as being "as-built", or make any necessary revisions to match the "as-built" condition. Thus, the original field fabrication sheet will become the "as-built" drawing of the assembly showing the field run piping locations and construction details.

The performance tests to be conducted on systems, components, etc. after the installation is complete will include hydrostatic/leak, electrical and instrumentation pre-operational in accordance with written and approved procedures. In addition, system and components will be flushed and cleaned to satisfy the level of cleanliness outlined in the Cleaning Requirement Document.

The combined primary stresses produced by the maximum hypothetical earthquake are maintained at less than or equal to 120 percent of the code allowable stresses from ANSI B31.1-0-1967, plus code case N-7 for durations up to one percent of the operating period.

As required by ANSI B31.7, Paragraph 1-701.5.4, piping systems will be observed during startup and initial operation by qualified personnel to ascertain that these systems are properly supported and/or restrained to ensure that piping vibration is not excessive. Where, in the opinion of the qualified individual, conditions exist detrimental to reliable operation corrective action will be taken, e.g., additions or modifications of support or restraints. In the event that the vibration is unacceptable and where an additional support does not correct an undesirable condition or cannot be provided, data will be recorded at points of maximum vibration. This data will then be used as input for analytical evaluation to correct the condition.

Also, during system heatup in the hot functional tests the piping will be observed for the following:

1. Assure that hangers, supports and seismic restraints do not interfere with piping expansion.

2. Assure that piping expansion does not interfere with equipment or other structures.

In addition, at pre-determined points, markers shall be attached to the pipe and referenced to fixed points on the building structure or fixed extensions of the building structure. Such selected points shall be observed and the thermal movements recorded and compared with those predicted.

Operational tests performed to verify piping designs will consist of starting and stopping makeup and purification pumps, reactor coolant pumps. Decay heat pumps exercise of high pressure injection valves, and operation of the pressurizer relief valves.

The results of these various analyses have been compared with allowable stress values for the various conditions and are as follows:

(1) Primary stresses for operation during the maximum hypothetical earthquake (0.10g horizontal ground acceleration) did not exceed 1.2 x S_h (CODE Tables A-1 & A-2 plus Code Case N-7).

(2) Thermal stresses did not exceed S_A as defined by CODE paragraph 102.3.2.

(3) Pressure stresses were calculated in accordance with CODE paragraph 102.3.2.

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