FLORIDA POWER CORPORATION
CRYSTAL RIVER UNIT NO. 3
GENERATING STATION

STRUCTURAL EVALUATION FOR FSAR

## 3.3 WIND AND TORNADO CRITERIA

The design wind velocity for the seismic Category I (FSAR Class I) structures is 110 mph at 30 feet above ground based on a recurrance interval of 100 years. All seismic Category I (FSAR Class I) components and equipment are protected by being housed in tornado resistant structures, or are provided with tornado missile shields. The design tornado for such structures is a 300 mph maximum tangential velocity. The simultaneous atmospheric pressure drop is 3 psi in 3 seconds.

ASCE Paper No. 3269 was utilized to determine the loads resulting from these wind and tornado effects. The load factor associated with wind load is 1.25 against the required ultimate capacity for concrete. For tornado loads concrete structures were designed for a load factor of 1.0. Steel structures were designed in accordance with the AISC specifications (1963 Edition).

The criteria used in the design of Seismic Category I (FSAR Class I) structures to account for the loadings due to specified winds and tornadoes postulated to occur at the plant site provide a conservative basis for engineering design and the method of determining the forces on the structure will adequately assure that such environmental forces represent the loadings imposed on the structure.

The use of these loading criteria provides reasonable assurance that, in the event of winds or tornadoes, the structural integrity and safety function of Seismic Category I (FSAR Class I) structures will not be impaired by the specified environmental forces. Conformance with these criteria is an acceptable basis for satisfying

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the requirements of AEC General Design Criterion #2.

The Seismic Category I (FSAR Class I) structures are so arranged on the plant site (or protected) such that any interaction between non-Category I (FSAR Class I) and Seismic Category I (FSAR Class I) structures, in the event of winds or tornadoes damaging non-Category I (FSAR Class I) structures, is not expected to affect the structural integrity of Seismic Category I (FSAR Class I) structures, systems, or components. The criteria in the design arrangement and the means employed for protection of Seismic Category I (FSAR Class I) and non-Category I (FSAR Class I) structures are an acceptable basis for compliance with the provisions of AEC General Design Criteria #2 and #4 as related to structures.

3.4 WATER LEVEL (FLOOD) DESIGN CRITERIA

The facility's major structures and buildings are located or constructured so as to be undistrubed by the maximum water level which is due to the Probable Maximum Hurricane. The design hydraulic force on facility structures included both the static and dynamic effects from the hurricane.

The use of these design loading criteria provides reasonable assurance that, in the event of flooding, the Seismic Category I (FSAR Class I) structures can be expected to withstand the specified environmental forces without impairment of their structural integrity and safety function. Conformance with these criteria is an acceptable basis for satisfying the requirements of AEC General Criteria #2 and #4 as related to environmental design basis for structures.

3.5 MISSILE PROTECTION

The tornado generated missiles include a spectrum of possible items that could be dislodged during tornadic winds and become missiles.

The selection of missiles is a wood plank, a wooden utility pole, a schedule 40 pipe and an automobile. The approach to determining missile effects on structures makes use of the NDRC (National Defence Research Council) formula with modifications suggested in U. S. Army Technical Manual TM 5-1300 for penetration resistance. Potential interior missiles are generally controlled by reinforced concrete and steel barriers and missile shields which are provided with a 25% margin in energy absorption capacity.

The criteria used in the design of Seismic Category I (FSAR Class I) structures to account for the loadings due to specified missile impacts postulated to occur at the plant site provide a conservative design basis for determining the forces on the structure to assure that such impact forces will not penetrate structures, shields, and barriers beyond acceptable limits as governed by the strength and resistance offered by such structures, shields and barriers.

The use of these design bases for missile protection provides reasonable assurance that, in the event of the generation of the postulated missiles, resulting loads and effects will not impair the structural integrity of Seismic Category I (FSAR Class I) structures, or result in any loss of protection intended for systems and components contained by such structures. Conformance with these design loading criteria is an acceptable basis for satisfying the AEC General Design Criteria #2 and #4.

## 3.7.1 SEISMIC INPUT

The seismic design response spectra indicate amplification factors of 2.7 at the period of 0.8 seconds, of 2.0 at the period of 0.17 seconds and of greater than 1 in the period range of 0.03 to 0.17 seconds for 2% damping.

The structure and equipment damping is in accordance with the damping factors which have been accepted for all recently licensed plants. The modified time history used for component equipment design is adjusted in amplitude and frequency to envelope the response spectra specified for the site.

We conclude that the seismic input criteria used by the applicant provides an acceptable basis for seismic design.

## 3.7.2 SEISMIC SYSTEM ANALYSIS AND
## 3.7.3 SEISMIC SUBSYSTEM ANALYSIS

Modal response spectrum and time history methods for multi-degree-of-freedom systems form the bases for analyses of all major Category I structures, systems and components. Governing response parameters are combined by the square root of the sum of squares to obtain maxima when the modal response spectrum method is used. The absolute sum of responses has been used for in-phase closely spaced frequencies.

Two components of seismic motion are considered: one horizontal and one vertical. The total response is obtained by the absolute sum of the responses to the two components.

Floor spectra inputs used for design and test verification of structures, systems and components were generated from the time history method. Dynamic analysis of vertical seismic systems has been employed for all structures, systems and components where structural amplifications in the vertical direction are significant. System and subsystem analyses has been performed on an elastic basis. Effects on floor response spectra of expected variations of structural properties and damping have been accounted for by widening the response spectra peaks by ± 10%.

We conclude that the dynamic methods and procedures for seismic systems used by the applicant provide an acceptable basis for seismic design.

3.7.4 SEISMIC INSTRUMENTATION PROGRAM

The type, number, location and utilization of strong motion accelerographs to record seismic events and to provide data on the frequency, amplitude and phase relationship of the seismic response of the containment structure correspond to the recommendations of Regulatory Guide 1.12.

Supporting instrumentation will be installed on Category I structures, systems and components in order to provide data for verification of the seismic responses determined analytically for such Category I items.

We conclude that the Seismic Instrumentation Program proposed by the applicant is acceptable.

3.8.1 CONCRETE CONTAINMENT

The containment structure is a soil supported prestressed concrete containment in the form of a right vertical cylinder with a shallow dome and a conventionally reinforced concrete flat slab base. The inside surface of the containment will be steel lined in order to form a leak tight membrane.

The design of the prestressed concrete containment was based on the concepts of ACI 318-63 using the working stress desing procedures for the loading combinations representing the construction conditions and the normal operating conditions. Under the various accident conditions including earthquakes, wind or tornado the design criteria were based on the ultimate strength design procedures using load factors. The design criteria including the load combinations, stress allowables and analytical procedures that were utilized are consistent with those used on other similar prestressed concrete containments previously licensed such as Three Mile Island Unit No. 1, Palisades, Point Beach and Turkey Point.

The loads considered in the containment design include appropriate combinations of dead and live loads, thermal loads, loss-of-coolant accident induced loads and severe environmental loads such as earthquake loads, and wind and tornado loads. A test pressure load of 1.15 times the design accident pressure is also included.

The static analysis for the containment shell was based on classical thin shell theory. The allowable stress and strain limits were those defined in reference codes. For the loading combinations cited previously, reinforcing bar yield was the most significant limit. For specific critical areas such as the equipment hatch area there were additional detailed studies completed by the applicant. In general, finite element techniques were used in those situations.

The interior structures of the containment were designed for the same general conditions considered for the containment shell with, of course, differences in magnitude. The primary shield wall is designed for 170 psi and the secondary shield wall is designed for 15 psi with capability to 17.5 psi taking the reinforcing steel to yield. The secondary shield wall was, however, designed in accordance with ACI 318-71 in order to attempt to keep the components designed late in the construction of the facility consistent with the latest codes.

The construction was carried out using ACI 301-66, Specifications for Structural Concrete Buildings with the modifications enumerated in the SAR. Applicable sections of the ASME Boiler and Pressure Vessel Code, Section III and Section IX were used in conjunction with the construction and design of the steel liner and penetrations.

The testing of the containment will be as prescribed in a report entitled, "Preliminary Report on Structural Integrity Testing of Reactor Containment Structure", by Gilbert Associates, Incorporated, dated January 12, 1970. Strain measurement instrumentation consisted 70 instrumented and embedded steel reinforcing bars and rosettes on the liner plate at six general locations with additional rosettes around three typical penetrations. Displacements will be measured using jig transits, precision levels, invar tapes and linear variable displacement transducers. Four visual monitoring locations for cracking etc are defined totalling 1230 square feet of surface area which is to be closely monitored for cracking.

The tendon surveillance program proposed by the applicant does not meet Regulatory Guide 1.35 although the applicant has stated that there is no physical reason that would limit their ability to meet the Guide. The Structural Engineering Branch has reviewed the justifications presented by the applicant for the deviations from the Guide and has determined that the current state of experience with large tendon systems (2000 kips) is not extensive enough to permit acceptance of the applicant's proposed program. Consequently it is the position of the Regulatory Staff to require that the tendon surveillance program that will be incorporated into the Technical Specifications be in conformance with Regulatory Guide 1.35.

The criteria used in the analysis, design and construction of the concrete containment structure and the related interior structures to account for the loadings and conditions that are anticipated to be experienced by the structures during the service lifetime, are in conformance with acceptable codes, standards and specifications.

The use of these design criteria defining the applicable codes, standards and specifications; the load and loading combinations; the design and analysis procedures, the structural acceptance criteria; the materials, quality control and special construction techniques; and the testing, provided reasonable assurance that, in the event of winds, tornados, earthquakes and various postulated accidents occurring within the containment, the Seismic Category I containment structures will withstand the specified conditions without impairment of their structural integrity and safety function. Conformance with these criteria constitutes an acceptable basis for satisfying the requirements of AEC General Design Criteria #2, #4, #16 and #50.

## 3.8.2 DESIGN OF OTHER CATEGORY I STRUCTURES

Important Category I (FSAR Class I) structures other than containment include the auxiliary building, the control complex, the diesel generator building, the intermediate building and the intake structure. These structures were designed to basically the same criteria that were utilized for the containment structure. The exceptions are as follows: a strict application of the ACI 318-63 ultimate strength design with the Code specified load factors was used and there was a portion of the steel superstructure of the Auxiliary Building which was not designed against tornado missiles however the spent fuel pool is provided with a tornado missile shield.

The high energy pipe breaks hypothesized outside containment and the related interactions with structures have been addressed by the applicant in a report entitled, "Effects of High Energy Piping System Breaks Outside the Reactor Building", dated October 1, 1973 and amended November 6, 1973. Specific load combinations which were taken from a position document of the Structural Engineering Branch have been used. As a result of modifications to the facility based on the Branch positions, it is concluded that the effects associated with the high energy breaks outside containment can be adequately resisted by the structures.

The seismic Category I (FSAR) Class I structures were built from a composite of structural steel and reinforced concrete members. In general, the structures were designed as continuous systems with slabs, walls, beams and columns being integrated into the design. The design methods for reinforced concrete followed the ultimate strength design provisions of ACI-318. For structural steel design the AISC Specification was utilized.

The loading combinations used for the design of these structures included normal dead and live loads, wind and tornado loads, and earthquake loads.

The analyses were being based on elastic analysis procedures with the design executed using the ultimate strength design provision of ACI 318 for concrete and the working stress design provisions of the AISC Code for structural steel.

Construction practice for the Category I structures was accomplished in accordance with ACI-301 appropriately modified to account for the specialized nature of the construction.

It is concluded that the criteria used in the analysis and design of seismic Category I structures, to account for the loadings and conditions that are anticipated to be experienced by the structures during the service life time, are in compliance with acceptable codes, standards, and specifications.

The use of these design criteria defining the applicable codes, standards and specifications; the load and loading combinations; the design and analysis procedures; the structural acceptance criteria; the materials, quality control and special construction techniques; and the testing and inservice surveillance requirements, provide reasonable assurance that, in the event of winds, tornados, earthquakes and various postulated accidents, these seismic Category I (FSAR Class I) structures may be expected to withstand the specified conditions without impairment of their structural integrity and safety function. Conformance with these criteria constituted an acceptable basis for satisfying the requirements of AEC General Design Criteria #2 and #4.

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Section 3.3 Wind and Tornado Loadings

3.3-1 "Wind Forces on Structures," Final Report of the Task Committee on Wind Forces of the Committee on Load and Stresses of the Structural Division, Transactions of the American Society of Civil Engineers, 345 East 47th Street, New York, N. Y. 10017, Paper No. 3269, Vol. 126, Part II, 1961, p. 1124-1198.

Section 3.5 Missile Protection

3.5-1 A. Amirikian, "Design of Protective Structures," Bureau of Yards and Docks, Publication No. NAVDOCKS P-51, Department of the Navy, Washington, D. C., August 1950.

3.5-2 National Defense Research Committee, Effects of Impact and Explosion, Summary Technical Report of Division 2, Vol. 1, Washington, D. C., 1946.

3.5-3 R. C. Gwaltney, "Missile Generation and Protection in Light-Water-Cooled Power Reactor Plants," USAEC Report ORNL-NSIC-22, September 1968.

3.5-4 "Structures to Resist the Effects of Accidental Explosions," TM 5-1300, NAVFAC P-397, or AFM 88-22, Departments of the Army, the Navy and the Air Force, June 1969.

Section 3.8 Design of Category I Structures

3.8-1 and 3.3-1 American Institute of Steel Construction, "Specification for Design, Fabrication & Erection of Structural Steel for Buildings," 101 Park Avenue, New York, N. Y. 10017, 1963.

3.8-2 American Concrete Institute, "Building Code Requirements for Reinforced Concrete (ACI 318-63 & -71)," P.O. Box 4754, Redford Station, Detroit, Michigan 48219.

3.8-3 American Society of Mechanical Engineers and the American Concrete Institute, "Proposed Standard Code for Concrete Reactor Vessels and Containments," United Engineering Center, 345 East 47th Street, New York, N. Y. 10017.

3.8-4 American Society of Mechanical Engineers, "ASME Boiler and Pressure Vessel Code." Section III, United Engineering Center, 345 East 47th Street, New York, N. Y. 10017.