Progress Energy

Crystal River Nuclear Plant
Docket No. 50-302
Operating License No. DPR-72

Ref: 10CFR50.36

November 17, 2008
3F1108-03

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

Subject: Crystal River Unit 3 – License Amendment Request #303, Revision 0: Revision to Final Safety Analysis Report Sections 5.4.3, "Structural Design Criteria," and 5.4.5.3, "Missile Analysis," (TAC No. MD8919) - Response to Request for Additional Information

References:

1. CR-3 to NRC letter dated June 3, 2008, "License Amendment Request #303, Revision 0: Revision to Final Safety Analysis Report Sections 5.4.3, "Structural Design Criteria," and 5.4.5.3, "Missile Analysis""
2. NRC to CR-3 letter dated October 22, 2008, "Request for Additional Information Regarding License Amendment No. 303, Revision to Final Safety Analysis Report, Sections 5.4.3 and 5.4.5.3 (TAC No. MD8919)"

Dear Sir:

On June 3, 2008, Florida Power Corporation (FPC), doing business as Progress Energy Florida, Inc., submitted License Amendment Request (LAR) #303 (Reference 1) to modify the analysis methodology identified in the Crystal River Unit 3 (CR-3) Final Safety Analysis Report (FSAR), Section 5.4.3, "Structural Design Criteria," and 5.4.5.3, "Missile Analysis." By letter dated October 22, 2008, the Nuclear Regulatory Commission requested additional information related to LAR #303 (Reference 2).

Attachment 1 to this submittal provides a response to the request for additional information. Attachment 2 provides a markup of revised CR-3 FSAR pages and replaces the pages in reference 1 in their entirety.

No new regulatory commitments are made in this letter.

If you have any questions regarding this submittal, please contact Mr. Dan Westcott, Supervisor, Licensing and Regulatory Programs at (352) 563-4796.

Sincerely,

Dale E. Young

Dale E. Young
Vice President
Crystal River Nuclear Plant

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Attachments 1: Response to Request for Additional Information
2: Proposed Revised Final Safety Analysis Report Pages - Marked-Up Pages

xc: NRR Project Manager
Regional Administrator, Region II
Senior Resident Inspector

Progress Energy Florida, Inc.
Crystal River Nuclear Plant
15760 W. Powerline Street
Crystal River, FL 34428

A053
NRR

STATE OF FLORIDA

COUNTY OF CITRUS

Dale E. Young states that he is the Vice President, Crystal River Nuclear Plant for Florida Power Corporation, doing business as Progress Energy Florida, Inc.; that he is authorized on the part of said company to sign and file with the Nuclear Regulatory Commission the information attached hereto; and that all such statements made and matters set forth therein are true and correct to the best of his knowledge, information, and belief.

Dale E. Young

Dale E. Young
Vice President
Crystal River Nuclear Plant

The foregoing document was acknowledged before me this 17 day of November, 2008, by Dale E. Young.

Carolyn E Portmann

Signature of Notary Public
State of Florida

CAROLYN E. PORTMANN
Notary Public - State of Florida
My Commission Expires Mar 1, 2010
Commission # DD 524380
Bonded By National Notary Assn.

(Print, type, or stamp Commissioned Name of Notary Public)

Personally Known ✓ -OR- Produced Identification ______

PROGRESS ENERGY FLORIDA, INC.

CRYSTAL RIVER UNIT 3

DOCKET NUMBER 50-302 / LICENSE NUMBER DPR-72

ATTACHMENT 1

Response to Request for Additional Information

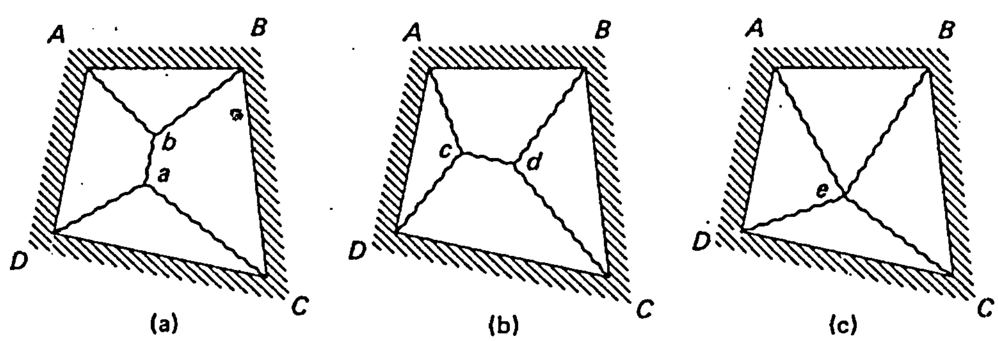
Response to Request for Additional Information

By letter dated October 22, 2008, the Nuclear Regulatory Commission (NRC) forwarded a letter to Florida Power Corporation (FPC) requesting additional information concerning License Amendment Request #303, Revision 0, "Revision to Final Safety Analysis Report Sections 5.4.3, "Structural Design Criteria," and 5.4.5.3, "Missile Analysis."" FPC hereby provides the following response to this Request for Additional Information.

1. *One of the limitations of the yield line method of analysis for slabs is an "upper bound" approach based on postulated collapse mechanisms, and consequently the failure load calculated for a slab may be higher than the true collapse load. Therefore, it is necessary to investigate all possible failure mechanisms (yield-line patterns) for any given slab and loading to confirm that the correct solution, giving the lowest failure load, has been found. Please explain how the above limitation was addressed in the application of the yield line theory to the east wall of the Auxiliary Building to ensure that the correct solution, giving the lowest failure load, has been found.*

CR-3 Response

For a flat rectangular slab, FPC investigated the three yield patterns as shown in the following generic figures.



The as-designed (as-built) wall thickness, boundary conditions, and reinforcement properties were used to find the lowest failure load postulated for these yield patterns. This question is further addressed in the response to RAI Question 5. The above figures are from "Reinforced Concrete Design," by Wang and Salmon (Reference 4) and are representative of all possible failure mechanisms (yield line patterns) for pressure loading. When using the analysis shown in this reference, the lowest potential failure loads are automatically developed.

2. *The licensee, under "Basic assumptions of the Yield Line Theory methodology," on Page 4 of Attachment 1 of the submittal, states that "Concrete is assumed to be ductile (linear stress distribution)." However, the Nuclear Regulatory Commission (NRC) staff does not believe that concrete is ductile and that the stress distribution in concrete for application of yield line analysis is linear. In fact, concrete is a brittle material, the reinforced concrete element (slab) section is assumed to be ductile and it is the strain distribution that is considered linear. Please clarify/correct this assumption.*

CR-3 Response

Basic assumptions of the Yield Line Theory methodology and its application to the Auxiliary Building Wall were taken from Reference 4. The intent of CR-3's comments in Attachment 1 of Reference 2 is that the slab system (concrete and steel reinforcement) will act in a ductile (elastic) manner up to the point of yielding in the reinforcement. From References 3 and 4, the fundamental assumption of the Yield Line Theory methodology is that the steel reinforcement is fully yielded to the maximum elastic point along the yield lines at what CR-3 defines as the failure point.

3. *The application of yield line analysis to reinforced concrete slabs is predicated upon available rotation capacity at the yield lines to attain the predicted ultimate loads. Please explain how it was ensured that the necessary ductility is present in the application of the yield line theory to the east wall of the Auxiliary Building. In the response, please include information on the tensile steel ratios in comparison to balanced design value for the wall.*

CR-3 Response

Since the slab reinforcement corresponds to the elastic distribution of moments in the slab, little rotation is required. Slabs that are lightly reinforced (which CR-3 considers the east wall of the Auxiliary Building to be) will have adequate rotational capacity to attain the collapse loads predicted by the Yield Line Theory methodology. Therefore, the Yield Line Theory methodology is acceptable for application to the east wall of the Auxiliary Building.

The tornado missile impact analysis is in terms of ductility ratios. The allowable ductility ratio is defined as the maximum permissible deflection of a structural system to the deflection at "effective yield" for the system. Recommended values for allowable ductility are given in Reference 5. The tornado missile impact force (2000 pound automobile) was less than the calculated impact force that would generate the permissible deflection. Therefore, if the ductility requirements are satisfactory for a concentrated load, then the uniform load using the Yield Line Theory methodology is assumed to satisfy any ductility criteria.

To quantify the margins CR-3 obtained in using the Yield Line Theory methodology, information is provided in the response to Question 5 in lieu of providing the tensile steel ratios to balanced design. CR-3 concluded that the elastic methodology of American Concrete Institute (ACI) Standard 318 was not acceptable with regards to the tornado missile and wind loading for the east wall of the Auxiliary Building, and therefore, did not calculate "balanced design" values in the CR-3 design basis calculations.

4. *The licensee, under "Basic assumptions of the Yield Line Theory methodology," on Page 4 of Attachment 1, states that "The structure is collapsing because of the moment, not by other failure mechanisms such as shear or bend." The NRC staff notes that the terms "moment" and "bend" represent the same response behavior of a structural element to loading. Please define each term as it is used in the submitted license amendment request (LAR). The NRC staff notes that the intended assumption in the above statement should be that the yield line analysis focuses entirely on the flexural capacity of the slab and it is presumed that earlier failure will not occur due to shear or torsion. Given that the east wall of the Auxiliary Building at Crystal River is 2 feet thick, please explain how the above*

assumption of the yield line theory was verified in the LAR. In the response, please include information on parameters such as wall dimensions, span to depth ratio and boundary conditions used in the application of the yield line analysis to the east wall of the Auxiliary Building for the loads and load combinations considered.

CR-3 Response

For the analysis, the wall drawings and as-built walkdowns were performed to determine characteristics that would cause shear or punching shear concerns along the postulated yield-line patterns. For identified occurrences of punching shear or torsion, no wall thickness discontinuities were found. As such, premature failure of the wall due to punching shear or torsion will not occur. It was concluded that the flexural capacity of the wall system would be the controlling failure mechanism.

The analysis included the following as analysis parameters (boundary conditions):

- The wall dimensions in the vertical direction are based on the nominal distance between floor levels (Floor Elevation 143' – Floor Elevation 119' = 24')
- The wall dimensions in the horizontal direction are based on the worst case distance between wall pilasters (24' was used)
- The end conditions were assumed "fixed" along the boundary of the "slab system"
- The as-designed reinforcement sizes and spacing were used in the evaluation

Reference the figure included with CR-3's response to Question 5 (below) for further information on the assumed boundary conditions.

5. *Please provide a summary of the results of the yield line analysis of the east wall of the Auxiliary Building. Include a comparison of the predicted ultimate capacity of the wall to the applied load for the tornado wind, pressure drop and missile loads and load combinations considered. Please confirm if the yield line analysis was used for checking only the global (as opposed to local) response of this wall.*

CR-3 Response

The Yield Line Theory methodology was used to check the "global" response of the Auxiliary Building east wall. The "local" effects of a tornado missile strike have been previously reviewed (Reference Section 5.2.1.2.6 of the CR-3 FSAR) and were not included with this evaluation. The basic conclusions of the "local" effect of a tornado missile are that a 2 foot thick concrete wall is adequate to withstand missile penetration and secondary spalling.

The results of the Yield Line Theory methodology on the Auxiliary Building's east wall were based on reinforcement capacities as follows:

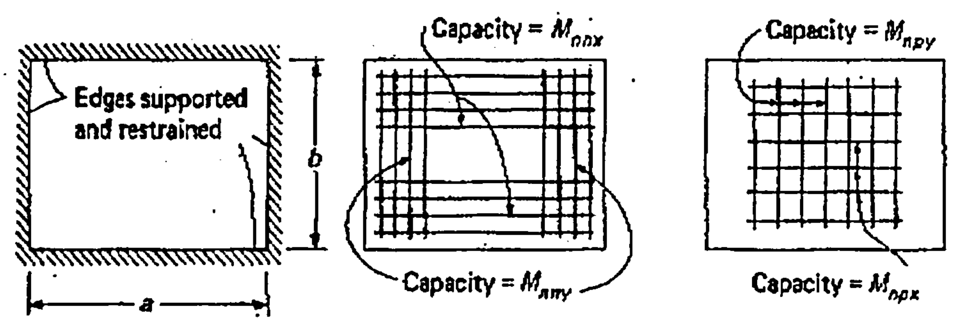
Parameters Dimensions:	$a = 24$ Feet
	$b = 24$ Feet
Reinforcement Capacity:	Top capacity, $M_{nnx} = 28.17$ ft – kip / ft
	Top capacity, $M_{nny} = 28.17$ ft – kip / ft
	Bottom capacity, $M_{npx} = 28.17$ ft – kip / ft
	Bottom capacity, $M_{npy} = 28.17$ ft – kip / ft

Three possible yield patterns for wind pressure loading were evaluated (see the response to Question 1 above). The governing capacity of the "global" wall system was computed to be 2.306 kips/square foot (ksf). Three design basis tornado wind load cases were calculated as follows:

Tornado Leeward Wind	= 0.081 ksf
3 psi Pressure Drop	= 0.432 ksf
Leeward Wind plus Pressure Drop	= 0.513 ksf

As shown, the ultimate, or collapse, pressure load of 2.306 ksf capacity of the wall using the Yield Line Theory methodology exceeds the design pressure applied loading of 0.513 ksf.

The tornado missile load case was analyzed using an assumed "circular fan" yield-line pattern. The ultimate "collapse" load was calculated to be 429,836 pounds. The design value of the worst case missile is 270,000 pounds. As shown, the Yield Line Theory methodology results provide an adequate margin against failure of the wall to protect systems or components.



(a) Dimensions (b) Top reinforcement (c) Bottom reinforcement

6. *Based on the submittal, it is the NRC staff's understanding that the yield line analysis methodology was used to check and qualify an as-constructed configuration of the east wall of the Auxiliary Building for tornado wind and tornado missile loads and load combinations, that was already designed (sizing the wall thickness and reinforcement) using the, ACI 318-63. The language used in the proposed Final Safety Analysis Report (FSAR) markup of Sections 5.4.3 and 5.4.3.2.2 gives the impression that this wall was "designed" using Yield Line methodology and that the yield line theory was also used for earthquake loads, which appears to be misleading. Please clarify the language of the markup of FSAR Sections 5.4.3 and 5.4.3.2.2 to accurately reflect application of the yield line analysis methodology for the east wall of the Auxiliary Building, which is to check/qualify the wall design for tornado wind and tornado missile loads as well load combinations.*

CR-3 Response

The calculations from the original plant design were found to contain an error for load combinations involving tornado loadings. These original plant design calculations were based on ACI 318 methodology and specified the current configuration of reinforcement size, spacing, and wall thickness. The wall was shown to be structurally adequate using the Yield Line Theory methodology for tornado wind and tornado missile loading. The Yield Line Theory methodology was not used to verify the walls for seismic loading since this was considered acceptable in the original design basis calculations. The proposed wording of Sections 5.4.3 will be revised to be more specific (see below). The wording in Sections 5.4.3.2.2 and 5.4.5.3 concerns the abnormal loading from tornados and is considered acceptable as written.

Suggested Rewording of the CR-3 FSAR Section 5.4.3:

5.4.3 Structural Design Criteria

This design has been based on ACI 318-63 "Working Stress Design" for normal operating conditions, and "Ultimate Strength Design" for tornado, earthquake, and missile impact conditions. The exception to this is the east wall of the Auxiliary Building. *Qualification of this wall for tornado wind pressure and tornado missile impact is only based on the Yield Line Theory methodology of concrete design.*

References:

1. NRC letter dated October 22, 2008, from Farideh E. Saba (Senior Project Manager, NRC), Request for Additional Information Regarding License Amendment Request No. 303, Revision to Final Safety Analysis Report, Sections 5.4.3 and 5.4.5.3
2. CR-3 letter 3F0608-06 dated June 3, 2008, from Dale E. Young, (Vice President, Crystal River Nuclear Plant) regarding Crystal River Unit 3 - License Amendment Request #303, Revision 0: Revision to Final Safety Analysis Report Sections 5.4.3, "Structural Design Criteria," and 5.4.5.3, "Missile Analysis"
3. Progress Energy, CR-3, Analysis Calculation S07-0037, Revision 0, "Structural Qualification of Auxiliary Building East and South Walls for Tornado Wind and Missile Loading"
4. "Reinforced Concrete Design," by Wang & Salmon, 4th and 6th Editions
5. American Society of Civil Engineers (ASCE), Manuals and Reports on Engineering Practice No. 58, "Structural Analysis and Design of Nuclear Plant Facilities"

PROGRESS ENERGY FLORIDA, INC.

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ATTACHMENT 2

Proposed Revised Final Safety Analysis Report Pages

Marked-Up Pages

d. The purge supply valve inside the reactor building is protected from debris which could foul it by ductwork extending downward through the refueling floor. The purge exhaust valve inside the reactor building is protected from debris by an 18 inch duct extension and wire mesh screen.

5.4 OTHER CLASS I STRUCTURES AND SYSTEMS

Other Class I structures are listed in Section 5.1.1.1. With the exception of the Dedicated Emergency Feedwater Tank Enclosure and the Diesel Driven Emergency Feedwater Pump Enclosure, other Class I structures are designed as discussed in Sections 5.4.1 through 5.4.3. Design of the Dedicated Emergency Feedwater Tank Enclosure is discussed in Section 5.4.6. Design of the Diesel Driven Emergency Feedwater Pump Enclosure is discussed in section 5.4.7.

5.4.1 STRUCTURAL DESIGN PARAMETERS

The loads used in design of these other Class I structures have been determined based on operating and accident requirements, as specified below, in addition to regular loads as required by applicable codes.

5.4.1.1 LOADS DURING NORMAL OPERATION

The loads due to normal operating conditions are:

a. Dead load
b. Live load
c. Wind load
d. Equipment loads
e. Design Basis Earthquake (DBE), see Section 5.2.1.2.9a

5.4.1.2 ABNORMAL LOADS (PROTECTION OF SAFEGUARDS)

These Class I structures which protect Class I Systems and equipment have been designed for such incidents as:

a. Tornado loads, see Section 5.2.1.2.6.
b. Main steam turbine missiles.
c. Tornado missiles, see Section 5.2.1.2.6.
d. Maximum Hypothetical Earthquake (MHE), see Section 5.1.2.1.

5.4.2 MATERIALS AND SPECIFICATIONS

The material and specifications for these other Class I structures are similar to those detailed in Section 5.2.2, except for the concrete which has a minimum compressive strength of 3,000 psi in 28 days (see Section 5.2.2.1).

5.4.3 STRUCTURAL DESIGN CRITERIA

This design has been based on ACI 318-63 "Working Stress Design" for normal operating conditions, and "Ultimate Strength Design" for tornado, earthquake, and missile impact conditions. *The exception to this is the east wall of the Auxiliary Building. Qualification of this wall for tornado wind pressure and tornado missile impact is only based on the Yield Line Theory methodology of concrete design.*

5.4.3.1 CODES

Same as Section 5.2.3.1 a, b, c, and e.

5.4.3.2 Loads

The design has been based upon normal operating loads, earthquake loads, and accident loads as described in Sections 5.4.1.1 and 5.4.1.2.

5.4.3.2.1 AT NORMAL OPERATING CONDITIONS

The stresses in the concrete and reinforcing steel resulting from combinations of those loads listed in Section 5.4.1.1 are in accordance with ACI 318-63, "Working Stress Design".

5.4.3.2.2 ABNORMAL LOADS

The other Class I structures have been designed to withstand short term tornado loadings, including tornado generated missiles where such structures house systems and components whose failure would result in an inability to safely shutdown and isolate the reactor. Structures that are so designed include the following:

a. Control building.

b. Auxiliary building, excluding the steel roof support structure.

   The concrete portion of the auxiliary building which houses Class I items is designed for tornado generated missiles. The spent fuel pool and new fuel vault have been evaluated for tornado generated missiles by calculation S06-0010.

   The roof was designed considering seismic loads but the roof will not act as a barrier against a tornado missile.

c. Diesel generator building, including the radiator exhaust air deflector wall and its support structure (EGX-2).

   The deflector wall is missile resistant, not missile proof. Structural failure (collapse) of the wall will not occur, but it is not designed to prevent local deformation of the structure or puncture of the wall (Ref. 68).

d. NSSS intake pump structure.

e. Intermediate building.

f. Exterior safety related piping and component missile shields.

The tornado design requirements are described in Section 5.2.1.2.6.

The structural design is in accordance with ACI 318-63, "Ultimate Strength Design," *except for the east wall of the Auxiliary Building, which has been based on the Yield Line Theory methodology.*

A detailed stress analysis of the internals under accident conditions is discussed in Babcock & Wilcox Topical Report BAW-10008.

Equipment such as safety features valves, tanks, and heat exchangers were stress analyzed using the equivalent static load method. The analysis includes evaluation of the equipment for normal and abnormal conditions. Seismic shock and vibration tests have been conducted on a valve operator which is typical of the valves used in the Engineered Safeguards (ES) Systems. The valve operator was tested at a 5.3g shock level at 35 cps with no discrepancies observed. A scan from 5 cps to 35 cps was made and no critical resonant frequencies were noted. The valve operator was shock and vibration tested in each of three different axes in a 2 minute "on" - 1 minute "off" cycle for a total of 3 times per axis. The unit was then electrically operated to the full-open and full-closed position, and all torque switches and limit switches functioned properly. All electrical and mechanical devices on the operator functioned properly.

The RCP motors have been dynamically tested by the supplier under operational conditions in a test loop. The tests demonstrated that the pump motor would operate satisfactorily under the worst anticipated vibratory loadings resulting from full flow conditions for Crystal River Unit 3. The natural frequency of the RCP and motor (above 25 cps) is appreciably above the fundamental seismic response spectra (10 cps) of the reactor coolant loop. The pump motors are capable of withstanding the calculated design earthquake loading with unaffected operational capability.

5.4.5.3 MISSILE ANALYSIS

The missile loading requirements for Class I structures are as in Section 5.4.3.2.3 for main steam turbine missiles, and as in Section 5.2.1.2.6 for tornado missiles.

The orientation of the pole to give the most critical load is end-on. For this condition, standard column formulas indicate that the pole will elastically buckle at a loading of 148 kips, which is considerably smaller than the crushing strength of either the pole or the concrete. The structural design was then checked by the ultimate strength provisions of ACI 318-63 for capacity to withstand this pole load, *except for the east wall of the Auxiliary Building, which has been based on the Yield Line Theory methodology.*

The analysis for the automobile is based on the approach used in Reference 40, which has been verified $\pm$20% in tests conducted by Dr. T. J. Hirsh of the Texas Transportation Institute at Texas A&M University, and by tests indicated in the Reference. This approach was extrapolated for the case of a 2,000 lb automobile traveling at 150 mph. Although the variation of deceleration is sinusoidal, due to the scatter of the test results the analysis was based on maximum deceleration to develop a maximum force applied to the structure. The structural design was then checked by the ultimate strength provisions of ACI 318-63 for capacity to withstand this automobile load, *except for the east wall of the Auxiliary Building, which has been based on the Yield Line Theory methodology.*

Missile analysis based on Standard Review Plan 3.5.1.4 (Reference 49) guidelines was used for the Emergency Feedwater Tank Enclosure and the Diesel Driven Emergency Feedwater Pump Enclosure. See sections 5.4.6 and 5.4.7 for more information.

5.4.5.4 SEISMIC DESIGN AND REVIEW OF CLASS I (SEISMIC) COMPONENTS AND EQUIPMENT

The seismic input, including any necessary feedback from structural and system dynamic analyses, were specified to the vendors of purchased Class I (seismic) components and equipment. Independent engineering review was made within the respective departments by persons other than the original Design Engineer.