Progress Energy

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

Ref: 10 CFR 50.90

June 3, 2008
3F0608-06

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

Subject: Crystal River Unit 3 – 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"

Dear Sir:

Pursuant to 10 CFR 50.90, Florida Power Corporation (FPC), doing business as Progress Energy Florida, Inc. (PEF), hereby submits License Amendment Request (LAR) #303, Revision 0. The proposed amendment would modify dictated analysis methodology in Sections 5.4.3, "Structural Design Criteria," and 5.4.5.3, "Missile Analysis," located in the Final Safety Analysis Report (FSAR) for Crystal River Unit 3 (CR-3). No CR-3 Improved Technical Specification (ITS) pages are affected by this LAR.

The amendment would change the methodology used to qualify the Class 1 structures, specifically the east wall of the Auxiliary Building, for wind and tornado missile loading. The current methodology uses the methods in American Concrete Institute (ACI) Standard 318-63, "Building Code Requirements for Reinforced Concrete," June 1963. The proposed methodology is the Yield Line Theory, which is an industry standard methodology and has been used at CR-3 for evaluating interior missiles inside the reactor building.

This license amendment request is being submitted per the requirements of 10 CFR 50.59, "Changes, Tests and Experiments." This change was determined to require prior NRC approval.

This letter establishes no new regulatory commitments.

The CR-3 Plant Nuclear Safety Committee has reviewed this request and recommended it for approval.

A001
NRR

If you have any questions regarding this submittal, please contact Mr. Dennis Herrin, Acting Supervisor, Licensing and Regulatory Programs at (352) 563-4633.

Sincerely,

Dale E. Young

Dale E. Young
Vice President
Crystal River Nuclear Plant

DEY/par

Attachments:

1. Background, Description of the Proposed License Amendment Request, Technical Analysis
2. Regulatory Analysis (No Significant Hazards Consideration Determination, Applicable Regulatory Requirements and Environmental Impact Evaluation)
3. Proposed Revised Final Safety Analysis Report Pages – Marked-Up Pages

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

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 3rd day of June, 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

LICENSE AMENDMENT REQUEST #303, REVISION 0

Background, Description of the Proposed License Amendment Request, Technical Analysis

Description

The proposed License Amendment Request (LAR) #303, Revision 0, will revise Crystal River Unit 3 (CR-3) Final Safety Analysis Report (FSAR) Sections 5.4.3, "Structural Design Criteria," and 5.4.5.3, "Missile Analysis," to include a methodology not currently contained in or referenced by FSAR Section 5.4. This methodology has been used at CR-3 for evaluating interior missiles inside the reactor building (FSAR Section 5.2.4).

This LAR is being submitted to reconcile discrepancies between the FSAR and the structural calculation for the east wall of the CR-3 Auxiliary Building.

Proposed Change Section

The proposed LAR will revise CR-3 FSAR Sections 5.4.3 and 5.4.5.3 to include a statement regarding the design of the east wall of the CR-3 Auxiliary Building.

Verbatim

FSAR Section 5.4.3 currently states that the design of Class I structures is based on American Concrete Institute (ACI) standard ACI 318-63, "Working Stress Design," for normal operating conditions, and "Ultimate Strength Design" for tornado, earthquake and missile impact conditions. FSAR Section 5.4.5.3, states that for Class I structures, the structural design shall be checked by the ultimate strength provisions of ACI 318-63. These sections are being revised to read:

(5.4.3) 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, *except for the east wall of the Auxiliary Building, which has been based on Yield Line Theory methodology.*

(5.4.3.2.2) 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.*

(5.4.5.3) 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 the capacity to withstand this 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 structure 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.*

Background

The CR-3 Auxiliary Building, excluding the steel roof support, is a Class I structure. As described in the CR-3 FSAR, a Class I structure is a structure whose failure might cause or increase the severity of a Loss of Coolant Accident (LOCA) or result in an uncontrolled release of radioactivity. Class I structures are also vital to safe shutdown and isolation of the reactor. CR-3 Class I structures, including the Auxiliary Building, contain and protect safety-related equipment.

The loads used in the design of these Class 1 structures have been determined based on operating and accident requirements, as specified below, in addition to regular loads as required by applicable codes:

Loads During Normal Operation

- Dead load
- Live load
- Wind load
- Equipment loads
- Design Basis Earthquake (DBE)

Abnormal Loads

- Tornado Loads
- Main Steam turbine missiles
- Tornado missiles
- Maximum Hypothetical Earthquake (MHE)

The tornado loading includes tornado generated missiles. Tornado design requirements are:

a. Tangential wind velocity of 300 miles per hour (mph).
b. An external pressure drop of 3 pounds per square inch gauge (psig).
c. Missile equivalent to a utility pole 35 feet long, 14 inches in diameter, weighing 50 lb./cubic foot. and traveling at 150 mph.
d. Missile equivalent to a one ton automobile traveling at 150 mph.

The CR-3 FSAR summarizes Class I structural design criteria in Section 5.4.3, "...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."

Upon review of the original design basis structural calculations for the east and south Auxiliary Building walls, it was discovered that calculations were not performed to reflect loading related to tornado driven missiles or tornado wind load combinations as described in the FSAR. An investigation and an assessment of the operability of the east and south walls of the Auxiliary Building was completed. The south wall was qualified using the methods described in the FSAR (ACI 318-63). Calculations indicate the east wall is operable and does not pose a nuclear safety risk.

Calculations to qualify the east wall were performed using the Yield Line Theory methodology. Utilization of the Yield Line Theory methodology to qualify the east wall is contrary to the FSAR Section 5.4.3 and 5.4.5 statement, "The design has been based on ACI 318-63." Therefore a revision to the FSAR is required to incorporate the Yield Line Theory methodology and revise the statements related to the structural design of the Auxiliary Building.

The Yield Line Theory methodology has been used as an acceptable methodology for internal missiles inside the reactor Building at CR-3. FSAR Section 5.2.4.1.3 of the FSAR documents the application of this methodology. Additionally, a letter from the NRC to Florida Power Corporation, dated September 1, 1973, discusses the use of the Yield Line Theory methodology as an acceptable technique for determining the failure capacity of concrete structures for a High Energy Line Break in Category 1 structures outside containment.

The application of the Yield Line Theory methodology for the Auxiliary Building east wall structural evaluation is acceptable based on the current FSAR discussion, the NRC letter from 1973, and calculation S07-0037, "Structural Qualification of Auxiliary Building East and South Walls for Tornado Wind and Missile Loading," which demonstrates that margin to failure still exists.

Technical Analysis

The proposed amendment will revise FSAR described methodology for determining ultimate yield strength of the east wall of the CR-3 Auxiliary Building. The design basis structural design criteria described in the FSAR for Class I structures is that of ACI 318-63. Upon review of the original design basis calculations for the Auxiliary Building, it was discovered that calculations were not performed on the east or south wall that reflect loading related to tornado driven missiles or tornado wind load combinations as described in the FSAR.

The east wall of the Auxiliary Building is approximately 2 feet thick, constructed of reinforced concrete. FSAR Section 5.2.1.2.6, "Tornado Load," has determined that a minimum of two feet of concrete provides sufficient resistance to the postulated missile spectrum and no additional penetration calculations are required.

Calculation S07-0037, was performed to confirm that both the east and south walls of the Auxiliary Building are OPERABLE. The calculation also qualifies the walls to the FSAR described postulated tornado driven missile and wind load combination using standard structural analysis techniques. The methods used in the calculation to qualify the Auxiliary Building walls consist of two parts. The first part analyzes the pressure loading of the wind while the second part analyzes the impact of a tornado borne missile.

The south wall was confirmed to be qualified per the methods of ACI 318-63 as described in the FSAR. No further action was required to demonstrate the compliance of the south wall to the current design and licensing basis.

Calculations were performed to qualify the east wall using methods of ACI-318-63 as described in the FSAR. These calculations were not successful. The stresses on the wall due to tornado wind pressure and missiles are not within the allowable limits of the ACI Code. However, the east wall can be qualified utilizing the Yield Line Theory methodology. Structural calculation S07-0037, was performed using the Yield Line Theory methodology and concludes that the ultimate strength of the Auxiliary Building east wall exceeds the applied tornado and pressure drop loads and no overall failure for the walls will occur due to missile impact.

The CR-3 "Design Basis Document (DBD) for Major Class I Structures," Tab: 1/3, states that these structures, built prior to 1985, were designed to the Ultimate Strength Design method for abnormal conditions and that such design conforms to the requirements of ACI 318-63. Note that ACI 318-63 does not directly address certain Design Basis Events such as tornado generated loads. In the Ultimate Strength Design method, the service loads (working loads) are increased sufficiently by factors to obtain the load at which failure is considered "imminent." The strength provided is based on an equivalent rectangular stress distribution with the maximum stress limited to 0.85 f'_c (uniaxial compressive strength). Note that the strength provided, which is commonly referred to as the "ultimate strength," is a Code defined value for strength and is not necessarily the "ultimate strength" of the section. In other words, this method does not necessarily predict the stress at which actual (ultimate) failure would occur.

The Yield Line Theory methodology offers a simplified analytical method that can determine the ultimate bending capacity of flat reinforced concrete plates subject to distributed and concentrated loads. Alternately, the Yield Line Theory methodology, combined with hinge rotation limits, can determine the energy absorption capacity of plates subject to impulsive and impact loads. This method is especially useful in evaluating existing structures that cannot be qualified using conservative simplifying analytical assumptions. The rotation limits for impulsive and impact effects per ACI 349, "Code Requirements for Nuclear Safety Related Concrete Structures," Appendix C, are used to determine the allowable out of plane deformation of the wall. When the rotation limits are combined with the ultimate bending capacity, the Yield Line Theory methodology performs the evaluation of the wall for impact and pressure loads.

The Yield Line Theory methodology of slabs is a relatively simple analysis method that investigates failure mechanisms of flat reinforced concrete slabs at the ultimate limit state. It establishes either the moments in an element (slab) at the point of failure or the load at which an element will fail.

Basic assumptions of the Yield Line Theory methodology are:

- The structure is collapsing because of the moment, not by other failure mechanisms such as shear or bend
- Concrete is assumed to be ductile (linear stress distribution)
- Axial (in-plane) forces are ignored
- Small deformations compared with the overall dimensions are assumed
- The steel reinforcement is fully yielded along the yield lines at failure
- The slab deforms plastically at failure and is separated into segments by the yield lines
- Bending and twisting moments are uniformly distributed along the yield lines, and they are the maximum values provided by the moment strengths in two orthogonal directions
- The elastic deformations are negligible compared with the plastic deformations; thus the slab (wall) parts rotate as plane segments in the collapse condition

The Yield Line Theory methodology is based upon the observed failure mechanisms in reinforced concrete slabs which suggest that all of the yielding in a slab occurs along a pattern of cracks (yield lines) emanating from the point of maximum deflection. As these cracks migrate to the edge of the slab, all of the tensile reinforcement that passes through a yield line yields, and plastic rotations occur. At this ultimate state, the slab fails. This theory is based on the principle that work done in yield lines rotating is equal to work done in loads moving.

The Yield Line Theory methodology is a less conservative methodology than ACI 318-63. However, the Yield Line Theory methodology is an accepted industry methodology and successful application demonstrates there remains margin to structural failure. The Yield Line Theory methodology has been used in engineering applications, both in design, as well as analysis, since K. W. Johansen published this theory in his doctoral thesis at the Danish Technical University.

There is no direct method of comparing the safety impact of the Yield Line Theory methodology over the ACI 318-63 methodology or vice versa. Both methods compare a calculated maximum value to an applied value, however, the calculated maximum is not the same under the two methodologies.

ACI 318-63 proscribes that a calculated applied bending moment be less than a calculated maximum bending moment. The maximum allowed moment depends directly on the physical characteristics (parameters) of the concrete wall (or slab). These parameters include the thickness of the wall; amount, size, and configuration of reinforcement; yield stress of the reinforcement; and the concrete design compressive strength. This calculated maximum allowable moment then has a safety factor applied (less than one) to derive the ultimate bending moment (capacity) of the concrete section. The applied moment depends on the actual dead loads, live loads, tornado loads, etc. that are to be analyzed. These applied loads are combined using the dictated load combinations of the FSAR or DBD to derive various applied bending moments. All of the resulting bending moments for the various load combinations need to be less than the ultimate bending moment of the concrete slab in order for the slab to be qualified per ACI 318-63. The comparison is essentially linear in that the moments (applied and capacity) are calculated per foot of concrete section.

The Yield Line Theory methodology takes similar ultimate bending moments for different directions of the slab and combines these moments in one of three possible yield patterns. These possible yield patterns consider the overall resistance of the slab. The controlling yield pattern depends on the physical properties of the concrete slab.

PROGRESS ENERGY FLORIDA, INC.

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ATTACHMENT 2

LICENSE AMENDMENT REQUEST #303, REVISION 0

Regulatory Analysis

No Significant Hazards Consideration Determination
Applicable Regulatory Requirements and
Environmental Impact Evaluation

No Significant Hazards Consideration Determination

The proposed License Amendment Request (LAR) #303, Revision 0, will revise the Crystal River Unit 3 (CR-3) Final Safety Analysis Report (FSAR) Sections 5.4.3, "Structural Design Criteria," and 5.4.5.3, "Missile Analysis." The Amendment will revise the analysis utilized to qualify specific portions of Class I structures.

1. Does not involve a significant increase in the probability or consequences of an accident previously evaluated.

The proposed LAR will revise the methodology used to qualify the east wall of the CR-3 Auxiliary Building for all expected and postulated loads including tornado wind and missile loading. The Yield Line Theory methodology is an industry standard that is used for the design and analysis of concrete slabs. The Yield Line Theory methodology is used for investigating the failure mechanisms of flat reinforced concrete slabs at the ultimate limit (failure point). In other words, this methodology determines either the moments in a slab at the point of failure or the load at which the slab will fail. A change in the methodology of an analysis used to verify qualification of an existing structure will not have any impact on the probability of accidents previously evaluated.

The analysis performed demonstrates that the CR-3 Auxiliary Building east wall will remain structurally intact following the worst case loadings assumed in the calculation. Therefore, this proposed change does not involve a significant increase in the probability or consequences previously evaluated.

2. Does not create the possibility of a new or different type of accident from any accident previously evaluated.

The function of the CR-3 Auxiliary Building wall is to house and protect the equipment that is important to safety from damage during normal operation, transients and design basis accidents. The use of the Yield Line Theory methodology for qualifying the east wall of the CR-3 Auxiliary Building has no impact on the capability of the structure. A calculation that uses the Yield Line Theory methodology demonstrated that the structure meets required design criteria. This ensures that the wall is capable of performing its design function without alteration or compensatory actions of any kind. No changes to any plant system, structure, or component (SSC) are proposed. No changes to any plant operating practices, procedures, computer firmware/ software will occur.

Therefore, the proposed change will not create the possibility of a new or different kind of accident from any previously evaluated.

3. Does not involve a significant reduction in the margin of safety.

The design basis of the plant requires structures to be capable of withstanding normal and accident loads including those from a design basis tornado. The Yield Line Theory methodology, as applied in an approved plant calculation, has demonstrated that the east wall of the CR-3 Auxiliary Building is capable of performing its design function. There is a slight reduction in conservatism between the method used for the remaining Class 1 structures, American Concrete Institute(ACI) standard 318-

63 and the Yield Line Theory methodology, but the calculation performed with the Yield Line Theory methodology validates the requirement that the east wall of the CR-3 Auxiliary Building will protect the important to safety SSCs located in proximity to the wall from damage.

ACI 318-63 utilizes conservative methods, and due to the assumptions and technique, results in a Code defined value for strength that is not the maximum limit. The Yield Line Theory methodology uses assumptions and techniques that will define the failure point. However, the calculation performed for the east wall of the CR-3 Auxiliary Building demonstrates that there is margin to this "failure point," and the strength of the wall exceeds the applied loads, including the tornado wind and pressure drop loads, and will not fail due to tornado missile impact.

Therefore, the proposed change does not involve a significant reduction in the margin of safety.

Based on the above, FPC concludes that the proposed amendment presents no significant hazards consideration under the standards set forth in 10 CFR 50.92(c) and, accordingly, a finding of "no significant hazards consideration" is justified.

Applicable Regulatory Requirements/Criteria

The proposed amendment is not a risk-informed change. The operation of the system will be the same as is currently considered in the current Crystal River Unit 3 Probabilistic Risk Analysis.

Environmental Impact Evaluation

10 CFR 51.22(c)(9) provides criteria for identification of licensing and regulatory actions eligible for categorical exclusion from performing an environmental assessment. A proposed amendment to an operating license for a facility requires no environmental assessment if operation of the facility in accordance with the proposed amendment would not:

(i) involve a significant hazards consideration,

(ii) result in a significant change in the types or significant increase in the amounts of any effluents that may be released offsite, and

(iii) result in a significant increase in individual or cumulative occupational radiation exposure.

FPC has reviewed proposed License Amendment Request #303, Revision 0, and concludes it meets the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Pursuant to 10 CFR 51.22(c), no environmental impact statement or environmental assessment needs to be prepared in connection with this request.

PROGRESS ENERGY FLORIDA, INC.

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ATTACHMENT 3

LICENSE AMENDMENT REQUEST #303, REVISION 0

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, *except for the east wall of the Auxiliary Building, which has been based on the Yield Line Theory methodology.*

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 ±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.