FLORIDA POWER CORPORATION
CRYSTAL RIVER UNIT 3
DOCKET NO. 50-302/LICENSE NO. DPR-72
LICENSE AMENDMENT REQUEST #238, REVISION 0
REVISION TO LICENSING BASIS FOR REACTOR COOLANT SYSTEM LEAKAGE DETECTION INSTRUMENTATION

LICENSE DOCUMENTS INVOLVED: **Improved Technical Specifications (ITS)**
Final Safety Analysis Report (FSAR)

PORTIONS: **ITS Bases B 3.4.14, "RCS Leakage Detection Instrumentation"**
FSAR Section 4.2.3.8, [RCS] "Leakage Detection"

SUMMARY OF CHANGES: Correct the stated ability of the gaseous radioactivity monitor to detect Reactor Coolant System (RCS) leakage of one gallon per minute (gpm) within one hour.

BACKGROUND:

The RCS leak detection system is provided to allow early notification of excessive RCS leakage inside containment. The system consists of Reactor Building (RB) sump level and RB atmosphere radiation monitoring. Atmosphere radiation monitoring is performed by RM-A6, which monitors both RB atmosphere particulate and gaseous radioactivity. The current licensing basis assumes both channels of RM-A6 are capable of detecting a change in RCS leak rate of one gpm within one hour. This requirement is based on the following:

- Initial issue of FSAR (CR-3 License Amendment 17, 4/10/72), Section 4.2.3.8, "Leak Detection," states that the response of RM-A6 is such that:

  > "...with design basis corrosion products in the reactor coolant...a one gpm leak to the reactor building atmosphere as vapor would give an alarm within 15 minutes."

  The same statement appears in Reference 1 and in the ITS Bases B 3.4.14, Amendment 149. However, no calculation could be located to support this conclusion. Recent calculations show that design basis corrosion products are a very small contributor to the total source term. Detection in 15 minutes based on corrosion products is clearly not possible for the gaseous monitor and highly improbable for the particulate monitor. (Note that a recent modification to RM-A6 revised the FSAR (Revision 24) and ITS Bases (Revision 17) regarding RCS leak detection capability. The approved documents state that with RCS activity levels assumed in the environmental report (0.1% failed fuel), a change in RCS leak rate of one gpm will be detected within one hour.)

- Regulatory Guide (RG) 1.45, Rev. 0 (1973), "Reactor Coolant Pressure Boundary Leakage Detection Systems," outlines acceptable means of providing Reactor Coolant Pressure Boundary (RCPB) leak detection. Regarding sensitivity and response time, the RG states that detection systems should be capable of detecting a leakage rate of one gpm in less than one hour. In support of CR-3's RCS leak-before-break (LBB) analysis and request for partial exemption from General Design Criterion 4 (GDC-4), FPC provided an evaluation of RCS leak detection systems using the criteria of RG 1.45 to demonstrate adequacy. This evaluation was submitted to the NRC in Reference 1, and stated that the three primary means of leak detection (Reactor Building Sump, Particulate Radiation, and Gaseous Radiation Monitors) are capable of meeting the detection criterion of one hour.

- The NRC Safety Evaluation Report (SER) of the Babcock and Wilcox Owners Group (B&WOG) analysis of postulated RCS pipe breaks, Reference 2, accepts LBB technology as an alternative to designing against dynamic loads associated with postulated ruptures of primary coolant loop piping. Acceptance is based, in part, on the fact that:

  > "B&WOG facilities have an RCS pressure boundary leak detection system which is consistent with the guidelines of Regulatory Guide 1.45, such that leakage of one (1) gpm in one hour can be detected."

  CR-3 is included in this group of B&WOG facilities by reference to the CR-3 docket. (Docket No. 50-302)

- The NRC SER supporting a partial exemption to GDC-4 for CR-3, based on LBB analysis, was provided in Reference 3. The evaluation included a discussion on Leak Detection Capability, in which it is stated:

  > "...reactor building sump level, airborne particulate and airborne gaseous monitors each have the capability of detecting a one gpm change in leak rate in less than one hour."

FPC initiated an effort to validate the capability of RM-A6 to detect RCS leakage as part of the CR-3 Restart System Readiness Review process in 1997. During this critical review, the inability of the gaseous monitor to meet the licensing basis was identified. This issue was reported to the NRC in Reference 4.

CHANGES TO ITS BASES B 3.4.14, "RCS Leakage Detection Instrumentation," and FSAR Section 4.2.3.8, "Leak Detection"

Description of Change:

ITS Bases B 3.4.14 and FSAR Section 4.2.3.8 will be changed to read:

> "The particulate monitoring channel is capable of detecting a change in RCS leak rate of one gpm within one hour, based on activity levels assumed in the Environmental Report (0.1% failed fuel). The predominant nuclide of detection for the particulate channel is Rb-88. The gaseous channel requires significantly more time to detect the same change in RCS leak rate (approximately 14 hours). This is due to the relatively long half-life of its predominant nuclide of detection, Xe-133."

Reason for Request:

FPC has identified that the gaseous radioactivity monitor is not capable of detecting an RCS leak of one gpm within one hour as previously identified in licensing documents. FPC has evaluated this change to the CR-3 ITS Bases and FSAR against the provisions of 10 CFR 50.59(a)(2), and has determined that this change represents an unreviewed safety question.

Justification for Request:

Licensing of the RM-A6 gaseous channel "as-is" is recommended based on the following:

- **Within the context of LBB, detectability of one gpm within one hour is not critical.** RG 1.45 requires that leak detection systems be capable of detecting significant RCPB degradation as soon after occurrence as practical to minimize the potential for gross boundary failure. Numerous documents regarding the application of LBB concepts to flaws and breaches in RCS primary loop piping include conclusions concerning the slow propagation of leaks to large breaks. For example, Reference 5, an Advisory Committee on Reactor Safeguards (ACRS) letter on the subject states:

  > "...there is no known mechanism in PWR piping material for developing a large break without going through an extended period during which the crack would leak copiously."

  Availability of a leak detection system meeting the intent of RG 1.45 was one of the criteria upon which the NRC based acceptance of LBB. However, within this context the one hour detection limit is somewhat arbitrary. In Generic Letter (GL) 84-04, "Safety Evaluation of Westinghouse Topical Reports Dealing with Elimination of Postulated Pipe Breaks in PWR Primary Main Loops," regarding Westinghouse plants, the NRC required that:

  > "Leakage detection systems at the facility should be sufficient to provide adequate margin to detect the leakage from the postulated circumferential throughwall flaw utilizing the guidance of Regulatory Guide 1.45, "Reactor Coolant Pressure Boundary Leakage Detection Systems," with the exception that the seismic qualification of the airborne particulate radiation monitor is not necessary. At least one leakage detection system with a sensitivity capable of detecting 1 gpm in ***4*** hours must be operable." (Emphasis added)

  The NRC SER of the Babcock and Wilcox Owners Group (B&WOG) analysis of postulated RCS pipe breaks, Reference 2, states that leak rate calculations performed by B&WOG used initial postulated through wall flaws larger in size than those of GL 84-04. Furthermore, the calculated leak rate through the postulated flaw is:

  > "...large relative to the staff's required sensitivity of plant leak detection systems; the margin is at least a factor of ten (10) on leakage."

  While the factor of ten margin is required by NUREG 1061, Volume 3, "Evaluation of Potential for Pipe Breaks," even this leak rate does not assure detection by the RM-A6 gaseous monitor within one hour. However, the alternate licensed leakage detection methods, Reactor Building sump level and RM-A6 particulate monitor, are capable of detecting a one gpm leak within one hour. Leakage detection by the particulate monitor, though, is dependent on RCS radioactivity levels. Detection of a one gpm leak by the particulate monitor within one hour assumes RCS radioactivity to be at a value equivalent to 0.1% failed fuel.

It should also be considered that the LBB analyses included the combination of both operating stresses and safe shutdown earthquake (SSE) loads when evaluating the propagation of leaking cracks into pipe breaks. As stated in Reference 2, the NRC applied the following acceptance criteria during the evaluation of the B&WOG LBB analyses:

> "(1) The loading conditions should include the static forces and moments (pressure, deadweight and thermal expansion) due to normal operation, and the forces and moments associated with the safe shutdown earthquake (SSE). These forces and moments should be located where the highest stresses, coincident with the poorest material properties, are induced for base materials, weldments and safe-ends.
>
> (3) A through-wall crack should be postulated at the highest stressed locations determined from (1) above. The size of the crack should be large enough so that the leakage is assured of detection with at least a factor of ten using the minimum installed leak detection capability when the pipe is subjected to normal operational loads.
>
> (4) It should be demonstrated that the postulated leakage crack is stable under normal plus SSE loads for long periods of time; that is, crack growth, if any, is minimal during an earthquake. The margin, in terms of applied loads, should be at least the $\sqrt{2}$ and should be determined by a crack stability analysis, i.e., that the leakage-size crack will not experience unstable crack growth even if larger loads (larger than design loads) are applied. This analysis should demonstrate that crack growth is stable and the final crack size is limited, such that a double-ended pipe break will not occur.
>
> (5) The crack size should be determined by comparing leakage-size crack to critical-size cracks. Under normal plus SSE loads, it should be demonstrated that there is a margin of at least 2 between the leakage-size crack and the critical-size crack to account for the uncertainties inherent in the analyses, and leakage detection capability. A limit-load analysis may suffice for this purpose; however, an elastic-plastic fracture mechanics (tearing instability) analysis is preferable."

The B&WOG analysis successfully demonstrated satisfaction of these criteria, illustrating that significant design margin exists that is independent of leakage detection capability. Furthermore, there is a low risk of this combination of events, an undetected RCS leak and an SSE, occurring concurrently.

In the context of the risk significance of this change, it is important to consider that RCS leak detection is a defense-in-depth mechanism for responding to initial indications of RCS leakage. Early detection of a leak will initiate operator action to perform a controlled shutdown of the plant using normal operating procedures and equipment. It is anticipated that such a response would be completed without leakage increasing beyond the capability of normal makeup sources, and without the initiation of engineered safeguards equipment.

However, if leakage were to exceed normal makeup capabilities, actuation of engineered safeguards equipment would occur, and the consequences of increased leakage would be enveloped by existing safety analyses of either small or large break loss of coolant accidents.

- **Additional diverse leak detection means are available.** ITS 3.4.14 requires that for MODES 1, 2, 3, and 4 the following leak detection systems must be operable:

  a. Reactor Building Sump Level **AND**

  b. Reactor Building Atmosphere Radiation Monitoring (particulate **OR** gaseous)

  When RCS radioactivity is low, background fluctuations may be large and necessitate setting the atmosphere gaseous radioactivity detector alarm well above median background values to avoid nuisance alarms. Since normal RCS radioactivity levels are significantly below the equivalent of 0.1% failed fuel, other diverse leak detection capabilities may be more effective than atmosphere gaseous radioactivity monitoring. These capabilities include RB pressure and Makeup tank level.

  In particular, Makeup Tank level, which is displayed and recorded in the Control Room, has been calculated to decrease at 1.9 inches per hour for every one gpm of RCS leakage. The level change due to larger leaks would be proportionate, and easily recognized. Control room operators routinely observe makeup tank level during normal operation.

  Although not described in the various LBB submittals, cooler condensate flow from each Reactor Building Cooling Unit (RBCU) is also monitored and alarmed in the Control Room. RBCU condensate flow switches have a setpoint of 1133 cc/min (0.30 gpm) and will provide indication of increasing humidity (due to RCS leakage, for example) in the RB. The ability of this instrumentation to detect a change in RCS leak rate of one gpm within one hour is dependent upon the initial RB humidity level and RBCU cooling water temperature. Alarm response procedures currently list RCS leakage inside containment as a potential cause of high condensate flow alarms. Between RB Pressure, Makeup tank level, RCS Inventory Balance and RBCU cooler condensate flow, significant diverse indication of RCS leakage is available to provide compensation for gaseous monitor sensitivity.

- **The probability is low that a leak will develop in RCS primary loop piping**. Reference 2 reported on probabilistic analyses of leaks developing in RCS primary piping, and concluded the following:

  > "Probabilistic fracture mechanics studies conducted by the Lawrence Livermore National Laboratories (LLNL) on both Westinghouse and Combustion Engineering nuclear steam supply system main loop piping [Reference 6] confirm that both the probability of leakage (e.g., undetected flaw growth through the pipe wall by fatigue) and the probability of a DEGB [double ended guillotine break] are very low. The results given in Reference [6] are that the best-estimate leak probabilities for Westinghouse nuclear steam supply system main loop piping range from 1.2×10^{-8} to 1.5×10^{-7} per plant year and the best-estimate DEGB probabilities range from 1×10^{-12} to 7×10^{-12} per plant year. Similarly, the best-estimate leak probabilities for Combustion Engineering nuclear steam supply system main loop

piping range from 1 x 10^{-8} per plant year to 3 x 10^{-8} per plant year, and the best-estimate DEGB probabilities range from 5 x 10^{-14} to 5 x 10^{-13} per plant year. In addition, LLNL recently conducted an evaluation of B&W nuclear steam supply main loop piping with the result that the best-estimate leak and DEGB probabilities are nominally identical to those calculated for the Westinghouse and Combustion Engineering studies. These results do not affect core melt probabilities in any significant way."

The preceding evaluation demonstrates that there is little risk associated with changing the licensing basis for the RM-A6 gaseous radioactivity leakage detection monitor. This conclusion is based on:

1. the availability of two separate means of RCS leak detection that meet the sensitivity criterion of RG 1.45,
2. consideration that the one hour detection limit is somewhat arbitrary,
3. the role of RCS leak detection as a defense-in-depth mechanism and not an engineered safeguards feature,
4. the availability of other diverse means of leakage detection, and
5. the low probability of occurrence predicted for leaks in RCS primary loop piping, and lower probability of their development into pipe breaks.

NO SIGNIFICANT HAZARDS CONSIDERATION EVALUATION

An evaluation of this proposed LAR has been performed in accordance with 10 CFR 50.91(a)(1) regarding significant hazard considerations, using the standards in 10 CFR 50.92(c). A discussion of these standards as they relate to this LAR follows:

(1) Involve a significant increase in the probability or consequences of an accident previously evaluated.

No. The function of the RM-A6 gaseous radioactivity monitor is to detect leakage from the RCS that may develop as a result of a flaw in a pressure boundary component. The previously identified capability to detect a one gpm leak within one hour would have provided an earlier warning of a small RCS leak than the actual detection capability now identified. However, RCS loss of coolant accidents evaluated in the FSAR cover the full spectrum of break sizes up to and including a complete severance of the largest RCS piping. The results of these analyses demonstrate that the consequences of such leaks are acceptable.

No other equipment relies on the capability of the RM-A6 gaseous monitor's ability to detect RCS leakage to perform its function. Likewise, no accident analyses rely on RCS leak detection for successful mitigation. Identifying the detector's actual capability to detect an RCS leak will not increase the probability of occurrence of an RCS leak. Detection time for an RCS leak was a consideration in granting a partial exemption to General Design Criterion 4. However, the capability of the RCS piping to resist propagation of a flaw from a leak into a break was based on material fracture analysis and material properties, not on the ability to detect low levels of leakage.

(2) Create the possibility of a new or different kind of accident from any accident previously evaluated.

No. The function of the RM-A6 gaseous radioactivity monitor is to detect RCS leakage that may develop from a flaw in a pressure boundary component. The monitor is a passive component that provides an indication of possible leakage for further operator evaluation. Identifying that a longer response time is required for the monitor to detect a small leak will not create the possibility of a new or different kind of accident. Existing analyses for small and large break loss of coolant accidents provide an evaluation of the full spectrum of RCS break sizes.

(3) Involve a significant reduction in a margin of safety.

No. The RM-A6 gaseous radioactivity monitor is included in plant technical specifications as one of two containment atmosphere RCS leak detection instruments required to be operable to satisfy a limiting condition for operation. If the RM-A6 particulate monitor is not operable, then the response time of the containment atmosphere monitor will be increased. RCS piping analyses have demonstrated that the propagation of a small primary loop leak into a pipe break would not occur rapidly. NRC acceptance of the applicable analyses included significant safety factors for the propagation of flaws into pipe breaks which were based on low probability stress combinations of normal plus safe shutdown earthquake loads. Considering the actual detection capability of the RM-A6 gaseous monitor and the existence of other diverse leak detection capabilities, detection of a leak in a relatively short period of time is anticipated. In the event an RCS leak developed into a pipe break, current accident analyses would bound the effects of the pipe break on and off site. Therefore, the possibility of increased time to detect an RCS leak does not represent a significant reduction in a margin of safety.

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 this proposed LAR 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.

REFERENCES:

1. FPC to NRC letter 3F1085-13, dated October 29, 1985, "Transmittal of Report Related to Request for Exemption from a Portion of 10 CFR 50 Appendix A, General Design Criteria 4"

2. NRC to Mr. L. C. Oakes, Chairman, B&W Owners Group Leak Before Break Task Force letter, dated December 12, 1985, "Safety Evaluation Of B&W Owners Group Reports Dealing With Elimination Of Postulated Pipe Breaks In PWR Primary Main Loops."

3. NRC to FPC letter 3N0586-30, dated May 23, 1986, forwarding the "Safety Evaluation by the Office of Nuclear Reactor Regulation Supporting Amendment No. 89 To Facility Operating License No. DPR-72, Florida Power Corporation, Et Al., Crystal River Unit No. 3 Nuclear Generating Plant, Docket No. 50-302"

4. FPC to NRC letter 3F1297-10, dated December 17, 1997, Crystal River Unit 3 Licensee Event Report 97-042, "Inadequate Engineering Evaluation Results in Loss of Diverse Reactor Coolant System Leak Detection Capability"

5. ACRS Letter from J. J. Ray to W. J. Dircks, dated June 14, 1983, "Fracture Mechanics Approach to Pipe Failure"

6. T. Lo, H. H. Woo, G. S. Holman, and C. K. Chou, "Failure Probability of PWR Reactor Coolant Loop Piping," presented at the ASME PVP Conference and Exhibition, June 17-21, 1984, San Antonio, Texas

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ATTACHMENT B

LICENSE AMENDMENT REQUEST #238, REVISION 0
Revision to Licensing Basis for Reactor Coolant System Leakage Detection Instrumentation

Proposed Revisions to Improved Technical Specification Bases and Final Safety Analysis Report in Strikeout/Shadow Format