PWROG White Paper : Proposed annotation to LCO 3.4.15 Bases, "RCS Leakage Detection Instrumentation," to include Regulatory Guide 1.45 considerations

Subject:

There have been recent NRC inspection and enforcement issues related to the sensativity and capability of radiation monitors to detect leakage from the Reactor Coolant System with the present-generation better fuel performance and improved chemistry resulting in lower primary coolant radioactivity concentrations. The NRC has questioned if the radiation monitors continue to meet the letter and spirit of Standard Technical Specifications (STS) Limiting Condition for Operation (LCO) 3.4.15, "RCS Leakage Detection Instrumentation," due to this improved performance. The guidance and intention of Regulatory Guide 1.45 will be considered.

Summary of finding:

The Nuclear Regulatory Commission (NRC) provided the finding in a letter to public petitioner Barry Quigley, dated July 18, 2002, which substantiated the existing STS and installed leakage detection instrumentation to support this function. This letter is attached, and a recommended annotation to the STS Bases follows to incorporate the aspects of this finding.

Recommended annotation to STS Bases for LCO 3.4.15 (note: the STS for NUREG-1432, Combustion Engineering Plants, is attached as typical):

The following will be added to the 'Background' section of the STS Bases for LCO 3.4.15:

RG 1.45 recommends using instruments with sensitivities of 10-9 microcuries per cubic centimeter (μCi/cc) for air particulate monitoring and 10-6 μCi/cc for the gaseous monitoring. Since the applicable monitors meet the specified sensitivity, they are designed in accordance with the guidelines of RG 1.45. With normal fuel performance and plant chemistry control (i.e.: clean primary coolant) the time required for the particulate and gaseous monitors to detect a small Reactor Coolant Pressure Boundary leakage exceeds 1 gpm in 1 hour. Although the airborne particulate and gaseous radioactivity monitors may not at all times be capable of detecting 1 gpm within 1 hour, they were designed in accordance with the sensitivities specified in RG 1.45.

The following will be added to the 'Applicable Safety Analysis' section of the STS Bases for LCO 3.4.15:

The RG 1.45 specified sensitivity of radiation detection systems (a 1-gpm leak rate in 1 hour) was based on expected activity levels as identified in the initially licensed environmental report. Based on understanding of reactor coolant pressure boundary (RCPB) degradation mechanisms and LBB technology, the detection of a 1-gpm leak rate in a 1-hour time frame for the gaseous and particulate monitors is not critical to maintaining RCPB integrity. When considered in conjunction with other diverse and less sensitive leakage detection methods, the availability of at least one detection method that is capable of detecting a 1-gpm leak rate increase within [1 hour] provides adequate LBB detection capability. Therefore, the particulate and gaseous radioactivity monitors are considered OPERABLE even though they may not be capable of detecting 1 gpm within 1 hour due to insufficient primary activity level

Background:

In a July 18, 2002 NRC letter to Barry Quigley, the NRC stated in response to question 1 that if the monitors meet the specified sensitivity in RG 1.45, they are designed in accordance with Regulatory Guide (RG) 1.45 and are consistent with the guidelines of the RG.

The response to question 2 says that all plants are meeting the intent of RG 1.45 and that the availability of at least one detection method that can detect a 1-gpm leak rate increase within 1 hour (or 4 hours in some cases) provides adequate Leak-Before Break (LBB) detection capability. In the response to question 3, the NRC stated the current RG 1.45 specified sensitivity of radiation detection systems (a 1-gpm leak rate in 1 hour) was based on expected activity levels as identified in the individual plant's environmental report and based on the current understanding of reactor coolant pressure boundary (RCPB) degradation mechanisms and LBB technology, the detection of a 1-gpm leak rate in a 1-hour time frame is not critical to maintaining RCPB integrity and the detector response time could be extended.

Some excerpts from this letter are included below (underlining added for emphasis):

"We have discussed the issue of operability and meeting the guidance of RG 1.45 at reduced coolant activity levels in a number of safety evaluations (as you are probably aware, RGs are not regulatory requirements). In a June 18, 1996, safety evaluation for ANO, Unit 2, the staff concluded that although the airborne particulate and gaseous radioactivity monitors may not at times be capable of detecting 1 gpm within 1 hour, they were designed in accordance with the sensitivities specified in RG 1.45. RG 1.45 recommends using instruments with sensitivities of 10-9 microcuries per cubic centimeter (μCi/cc) for air particulate monitoring and 10-6 μCi/cc for the gaseous monitoring. Since the applicable monitors meet the specified sensitivity, they are designed in accordance with RG 1.45. The staff's overall conclusion was that the leakage detection systems at ANO, Unit 2, were consistent with the guidelines of RG 1.45. A similar conclusion was drawn by the staff in a June 14, 1999, safety evaluation for the Crystal River, Unit 3 leakage detection systems where the gaseous radioactivity monitor was only capable of detecting a 1-gpm leak rate within 14 hours. In both of these cases (modifications were made at ANO, Unit 2) the sump level/flow monitoring systems were capable of detecting a 1-gpm leak rate within 1 hour."

"GDC 30 requires that "means shall be provided for detecting and, to the extent practical, identifying the location of the source of the reactor coolant leakage." As discussed in our response to Question 1 above, the staff believes that the intent of RG 1.45 is being met at all plants; therefore, there is reasonable assurance that GDC 30 is being met. Furthermore, when considered in conjunction with other diverse and possibly less sensitive leakage detection methods, the availability of at least one detection method that is capable of detecting a 1-gpm leak rate increase within 1 hour (or 4 hours in some cases) provides adequate LBB detection capability. In addition to the particulate and/or gaseous radioactivity monitor, plants are equipped with a sump level and/or sump flow monitor which is usually capable of detecting a 1- gpm leak rate within a 1- to 4-hour period. Some plants may also have containment cooler condensate flow-rate monitors with the same sensitivity. In addition, as discussed in RG 1.45, there are a number of other leakage detection methods available that are not included in the plant technical specifications that contribute to the assurances that GDC 30 is being met."

"With respect to revising RG 1.45, "Reactor Coolant Pressure Boundary Leakage Detection Systems," the staff's intention was to eventually revise it to include newer methodologies and to address the outcome of ongoing and/or future activities associated with LBB technology.

However, this effort will involve considerable time and effort. In the meantime we are considering an interim revision to address the detector sensitivities associated with the actual coolant activity levels existing at power plants today. The current RG 1.45 specified sensitivity of radiation detection systems (a 1-gpm leak rate in 1 hour) was based on expected activity levels as identified in the individual plant's environmental report. Based on our current understanding of reactor coolant pressure boundary (RCPB) degradation mechanisms and LBB technology, the detection of a 1-gpm leak rate in a 1-hour time frame is not critical to maintaining RCPB integrity and the detector response time could be extended."

For example, in a June 14, 1999 NRC amendment for Crystal River, the NRC states that RG 1.45 states that it is acceptable to use the values in the environmental report in analyzing the sensitivity of airborne particulate or gaseous radioactivity leak detection system. The NRC found that it was acceptable for the gaseous monitor to detect 1 gpm in 14 hours based on the diverse methods of leak detection which are available.

Attachments:

1. **Letter, Brian W. Sheron (NRC) to Barry Quigley, dated July 18, 2002**
2. **Sample markup of LCO 3.4.15 Bases.**

ATTACHMENT 1

July 18, 2002

Mr. Barry Quigley
3512 Louisiana Rd.
Rockford, Illinois 61108

Dear Mr. Quigley:

Thank you for your May 17, 2002, letter in which you expressed concerns about the capability of the reactor coolant system (RCS) leakage detection systems at operating nuclear power plants to detect a 1 gallon-per-minute (gpm) RCS leak rate within 1 hour. You asked three questions and inquired about the status of generic activities related to RCS leakage detection systems. The enclosure to this letter provides our answers to your questions and the status of generic activities related to RCS leakage detection. Although your letter, and hence our response, focused on pressurized-water reactors (PWRs), the same issue may also apply to boiling water-reactors (BWRs).

We would like to point out that in light of leak-before-break studies performed since the issuance of Regulatory Guide (RG) 1.45, "Reactor Coolant Pressure Boundary Leakage Detection Systems," we have determined that the detector response time (1 hour) specified therein is conservative with respect to crack growth in piping. However, with respect to the recent control rod drive mechanism penetration cracking events, the sensitivity (1 gallon per minute) specified in RG 1.45 cannot detect the small leak rates associated with these type of events. Such small leakage rates must be detected via inservice inspection programs, boric acid walkdowns or other inspection techniques.

For most component and piping degradation mechanisms, the probability of crack growth resulting in a loss-of-coolant accident (LOCA) prior to detection by one of the reactor coolant system leakage detection systems is extremely low. This conclusion may be drawn due to: (1) the overall diversity and redundancy of the leakage detection systems, (2) relatively slow rates of stable crack growth for most cracking mechanisms, and (3) the low probability of an abnormal loading event (e.g., an earthquake) which could lead to catastrophic failure of the component or piping. Nuclear power plants are designed to provide adequate core cooling following any postulated LOCA up to and including a break equivalent in size to the double-ended rupture of the largest pipe in the RCS. This design feature, coupled with the extremely low likelihood of undetected crack growth resulting in a LOCA, leads us to conclude that the risk significance of this issue is low.

Thank you for expressing your concerns to the NRC. I trust the information provided in the enclosure to this letter is responsive to your concerns.

Sincerely,

/RA/

Brian W. Sheron, Associate Director
for Project Licensing and Technical Analysis
Office of Nuclear Reactor Regulation

Enclosure: As stated

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Three questions and the answers

Your questions and our answers are provided below:

1. *In recent years, plants have exhibited better fuel performance and improved chemistry resulting in less primary coolant radioactivity concentrations than was assumed when plants were originally licensed. In light of this NRC statement and the NRC safety assessment of Region II concerns regarding the discrepancies of containment radiation monitor sensitivities at St. Lucie and Turkey Point (June 24, 1998, ADAMS ML011760038), has NRC been aware for the last four years that plants are operating outside the condition of their licenses?*

Regulatory Guide (RG) 1.45, "Reactor Coolant Pressure Boundary Leakage Detection Systems," is not a license condition but it is part of the current licensing basis for some plants. We are aware that plants may occasionally operate outside their licensing bases and we expect licensees to take appropriate actions as required. Appropriate actions may include entering applicable technical specification action statements, revising the safety analysis report pursuant to 10 CFR 50.59, and if necessary, informing the staff in accordance with 10 CFR 50.72(b) or 50.73(a)(2)(i). We also rely on our own inspection staff to help monitor and provide further assurance that plants are being operated within their licensing bases.

We have discussed the issue of operability and meeting the guidance of RG 1.45 at reduced coolant activity levels in a number of safety evaluations (as you are probably aware, RGs are not regulatory requirements). In a June 18, 1996, safety evaluation for ANO, Unit 2, the staff concluded that although the airborne particulate and gaseous radioactivity monitors may not at times be capable of detecting 1 gpm within 1 hour, they were designed in accordance with the sensitivities specified in RG 1.45. RG 1.45 recommends using instruments with sensitivities of 10^{-9} microcuries per cubic centimeter (μCi/cc) for air particulate monitoring and 10^{-6} μCi/cc for the gaseous monitoring. Since the applicable monitors meet the specified sensitivity, they are designed in accordance with RG 1.45. The staff's overall conclusion was that the leakage detection systems at ANO, Unit 2, were consistent with the guidelines of RG 1.45. A similar conclusion was drawn by the staff in a June 14, 1999, safety evaluation for the Crystal River, Unit 3 leakage detection systems where the gaseous radioactivity monitor was only capable of detecting a 1-gpm leak rate within 14 hours. In both of these cases (modifications were made at ANO, Unit 2) the sump level/flow monitoring systems were capable of detecting a 1-gpm leak rate within 1 hour.

It is not necessary to detect a 1-gpm leak rate within 1 hour in order to achieve the goal of reasonable assurance that such leaks will be detected in time to prevent large piping failures. For instance, Generic Letter (GL) 84-04, "Safety Evaluation of Westinghouse Topical Reports Dealing With Elimination of Postulated Pipe Breaks in PWR Primary Main Loops," recognized that having one leakage detection method operable that could detect a 1-gpm leak rate within 4 hours provided sufficient safety margin to support LBB approval. Likewise in a number of safety evaluations, the staff recognized that an airborne gaseous radioactivity monitor that could detect a 1 gpm leak rate within a 9-18 hour period was acceptable. This was based on the availability of other detection methods, including a sump level/flow monitoring system that was capable of detecting a 1-gpm leak rate within 1 hour.

We understand that significant decreases in radioactivity levels at many, if not all, of the plants, have created inconsistencies between what we find acceptable and what is stated in RG 1.45 and we need to reconsider the prioritization of a first revision to RG 1.45. However, it is also prudent to wait for the completion of the generic studies associated with the events at V.C. Summer and Davis-Besse to determine if new requirements are necessary.

You also referred to the upcoming generic activities referenced by the staff in the NRC safety assessment of the Region II concerns at St. Lucie and Turkey Point (TIA-019), and stated that you have been unable to find the results of these activities in the public domain. Please refer to the status of ongoing generic activities discussion which follows our answer to Question 3.

2. *In light of a number of Licensee Event Reports (LERs) where plants have been unable to meet the requirements of Regulatory Guide 1.45, what reasonable assurances, based on objective data, can NRC provide the public that General Design Criterion (GDC) 30 is being met?*

GDC 30 requires that "means shall be provided for detecting and, to the extent practical, identifying the location of the source of the reactor coolant leakage." As discussed in our response to Question 1 above, the staff believes that the intent of RG 1.45 is being met at all plants; therefore, there is reasonable assurance that GDC 30 is being met. Furthermore, when considered in conjunction with other diverse and possibly less sensitive leakage detection methods, the availability of at least one detection method that is capable of detecting a 1-gpm leak rate increase within 1 hour (or 4 hours in some cases) provides adequate LBB detection capability. In addition to the particulate and/or gaseous radioactivity monitor, plants are equipped with a sump level and/or sump flow monitor which is usually capable of detecting a 1-gpm leak rate within a 1- to 4-hour period. Some plants may also have containment cooler condensate flow-rate monitors with the same sensitivity. In addition, as discussed in RG 1.45, there are a number of other leakage detection methods available that are not included in the plant technical specifications that contribute to the assurances that GDC 30 is being met.

3. *The Technical Specifications (TS) allow a small amount of unidentified leakage, typically 1 gpm. The TS do not allow any RCS pressure boundary leakage. This may introduce a non-conservatism since operators may not be able to distinguish between unidentified leakage and the RCS pressure boundary leakage. In other words, how do they know it is not pressure boundary leakage?*

Since it is impractical, as discussed in RG 1.45, to eliminate all unidentified leakage, a 1-gpm limit for unidentified leakage at PWRs is conservative with respect to detection capability and known normal leak rates. Based on our experience, at many PWRs, the normal unidentified leak rate is somewhere between 0.1 and 0.3 gpm. The normal unidentified leak rates usually remain relatively constant following plant startup and a reasonable run-in time.

When an increase over this base rate occurs the leakage is initially classified as unidentified. As you suggest in Question 3, even though a possibility exists that the base leak rate and/or any increase over the base rate could be pressure boundary leakage, the 1-gpm technical specification limit minimizes the risk associated with that possibility. This is because, when you consider the through-wall flaw size necessary to provide 1 gpm of leakage, it is unlikely that such a flaw will grow to a size which could significantly threaten reactor coolant pressure boundary integrity under design basis conditions prior to being detected. Furthermore, based on our experience, we believe licensees are sensitive to this leak rate and generally do not wait until the 1-gpm limit is reached before taking actions to identify the source of any increase in leakage and taking appropriate action, including shutting down if necessary.

By virtue of the technical specifications, the staff does not allow plants to operate with any known primary pressure boundary leakage (0 gpm required by technical specifications). However, we do allow plants to operate with limited unknown leakage (up to 1 gpm for PWRs) as discussed above.

Status of Generic Activities Related to RCS Leakage

In your letter you referred to the generic activities mentioned in the staff's June 24, 1998, safety assessment of Region II concerns (TIA-019) about discrepancies in the containment radiation monitor sensitivities at St. Lucie Units 1 and 2, and Turkey Point Units 3 and 4. You also referred to Information Notice (IN) 2000-17, Supplement 2, "Crack in Weld Area of Reactor Coolant System Hot Leg Piping at V. C. Summer," dated February 28, 2001 in which the staff discusses other generic activities. You expressed concern that you could not find the results of any of these activities in the public domain. The results are not available in the public domain because these activities have not been completed. The following discussion describes the status of these activities and other related issues.

In TIA-019 the staff stated that the Office of Nuclear Regulatory Research was developing a regulatory guide (RG) for LBB to establish updated regulatory guidance on experience gained over the past years in the application of LBB technology. The basis for the RG is NUREG/CR-6765, "Development of Technological Basis for Leak-Before-Break Evaluation Procedures." It will be issued in the near future and will be available at the NRC public web site (http://www.nrc.gov).

In IN 2000-17, Supplement 2, the staff identified four generic issues:

- potential weaknesses in the ability of ASME Code-required nondestructive examination techniques to detect and size small inner-diameter stress corrosion cracks
- potential weaknesses in the ASME Code in that it allows multiple weld repairs which affect residual weld stress and primary water stress corrosion cracking (PWSCC)
- potential weaknesses in RCS leak detection systems
- questions regarding the continued applicability of "leak before break" analyses.

Work on the leak detection issue will begin when the other three issues are resolved. This is due to the possibility that the other issues could lead to new insights regarding the necessary sensitivity of RCS leakage detection systems.

With respect to revising RG 1.45, "Reactor Coolant Pressure Boundary Leakage Detection Systems," the staff's intention was to eventually revise it to include newer methodologies and to address the outcome of ongoing and/or future activities associated with LBB technology. However, this effort will involve considerable time and effort. In the meantime we are considering an interim revision to address the detector sensitivities associated with the actual coolant activity levels existing at power plants today. The current RG 1.45 specified sensitivity of radiation detection systems (a 1-gpm leak rate in 1 hour) was based on expected activity levels as identified in the individual plant's environmental report. Based on our current understanding of reactor coolant pressure boundary (RCPB) degradation mechanisms and LBB technology, the detection of a 1-gpm leak rate in a 1-hour time frame is not critical to maintaining RCPB integrity and the detector response time could be extended.

Attachment 2

B 3.4 REACTOR COOLANT SYSTEM (RCS)

B 3.4.15 RCS Leakage Detection Instrumentation

BASES

BACKGROUND

GDC 30 of Appendix A to 10 CFR 50 (Ref. 1) requires means for detecting and, to the extent practical, identifying the location of the source of RCS LEAKAGE. Regulatory Guide 1.45 (Ref. 2) describes acceptable methods for selecting leakage detection systems.

Leakage detection systems must have the capability to detect significant reactor coolant pressure boundary (RCPB) degradation as soon after occurrence as practical to minimize the potential for propagation to a gross failure. Thus, an early indication or warning signal is necessary to permit proper evaluation of all unidentified LEAKAGE.

Industry practice has shown that water flow changes of 0.5 gpm to 1.0 gpm can readily be detected in contained volumes by monitoring changes in water level, in flow rate, or in the operating frequency of a pump. The containment sump used to collect unidentified LEAKAGE [is] and the containment air cooler condensate flow rate monitor [are] instrumented to alarm for increases of 0.5 gpm to 1.0 gpm in the normal flow rates. This sensitivity is acceptable for detecting increases in unidentified LEAKAGE.

The reactor coolant contains radioactivity that, when released to the containment, can be detected by radiation monitoring instrumentation. Reactor coolant radioactivity levels will be low during initial reactor startup and for a few weeks thereafter until activated corrosion products have been formed and fission products appear from fuel element cladding contamination or cladding defects. Instrument sensitivities of 10^{-9} μCi/cc radioactivity for particulate monitoring and of 10^{-6} μCi/cc radioactivity for gaseous monitoring are practical for these leakage detection systems. Radioactivity detection systems are included for monitoring both particulate and gaseous activities, because of their sensitivities and rapid responses to RCS LEAKAGE.

Insert "A"

An increase in humidity of the containment atmosphere would indicate release of water vapor to the containment. Dew point temperature measurements can thus be used to monitor humidity levels of the containment atmosphere as an indicator of potential RCS LEAKAGE. A 1°F increase in dew point is well within the sensitivity range of available instruments.

BASES

BACKGROUND (continued)

Since the humidity level is influenced by several factors, a quantitative evaluation of an indicated leakage rate by this means may be questionable and should be compared to observed increases in liquid flow into or from the containment sump [and condensate flow from air coolers]. Humidity level monitoring is considered most useful as an indirect alarm or indication to alert the operator to a potential problem. Humidity monitors are not required by this LCO.

Air temperature and pressure monitoring methods may also be used to infer unidentified LEAKAGE to the containment. Containment temperature and pressure fluctuate slightly during plant operation, but a rise above the normally indicated range of values may indicate RCS LEAKAGE into the containment. The relevance of temperature and pressure measurements are affected by containment free volume and, for temperature, detector location. Alarm signals from these instruments can be valuable in recognizing rapid and sizable leakage to the containment. Temperature and pressure monitors are not required by this LCO.

APPLICABLE SAFETY ANALYSES

The need to evaluate the severity of an alarm or an indication is important to the operators, and the ability to compare and verify with indications from other systems is necessary. The system response times and sensitivities are described in the FSAR (Ref. 3). Multiple instrument locations are utilized, if needed, to ensure the transport delay time of the LEAKAGE from its source to an instrument location yields an acceptable overall response time.

INSERT "B"

The safety significance of RCS LEAKAGE varies widely depending on its source, rate, and duration. Therefore, detecting and monitoring RCS LEAKAGE into the containment area are necessary. Quickly separating the identified LEAKAGE from the unidentified LEAKAGE provides quantitative information to the operators, allowing them to take corrective action should leakage occur detrimental to the safety of the facility and the public.

RCS leakage detection instrumentation satisfies Criterion 1 of 10 CFR 50.36(c)(2)(ii).

Insert “A”:

RG 1.45 recommends using instruments with sensitivities of 10-9 microcuries per cubic centimeter (μCi/cc) for air particulate monitoring and 10-6 μCi/cc for the gaseous monitoring. Since the applicable monitors meet the specified sensitivity, they are designed in accordance with the guidelines of RG 1.45. However, note that with improved fuel performance and improved chemistry (i.e.: cleaner primary coolant) will have the necessary effect of extending the time required to detect a small Reactor Coolant Pressure Boundary leakage. Consequently, although the airborne particulate and gaseous radioactivity monitors may not at times be capable of detecting 1 gpm within 1 hour, they were designed in accordance with the sensitivities specified in RG 1.45.

Insert “B”:

Note: RG 1.45 specified sensitivity of radiation detection systems (a 1-gpm leak rate in 1 hour) was based on expected activity levels as identified in the initially licensed environmental report. Based on understanding of reactor coolant pressure boundary (RCPB) degradation mechanisms and LBB technology, the detection of a 1-gpm leak rate in a 1-hour time frame is not critical to maintaining RCPB integrity and the detector response time could be extended. That is, with primary coolant radioactivity concentrations less than design – e.g., by improved fuel performance and improved chemistry – then time to detect a small leakage could be extended. This condition of enhanced operations is not intended to be punitive or invalidate the OPERABILITY of the leakage detection instrumentation.