UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO AMENDMENT NO. 41 TO FACILITY OPERATING LICENSE NO. DPR-43

WISCONSIN PUBLIC SERVICE CORPORATION

WISCONSIN POWER AND LIGHT COMPANY

MADISON GAS AND ELECTRIC COMPANY

KEWAUNEE NUCLEAR POWER PLANT

DOCKET NO. 50-305

I. Introduction

By letters dated November 23, December 8, and December 23, 1981, Wisconsin Public Service Corporation (the licensee) submitted their proposed Amendment No. 48 to the Technical Specifications for the Kewaunee Nuclear Power Plant. The proposal requested changes for:

a) Allowable Control Rod Misalignment

b) Power Distribution Control

c) Control Rod Position Measurement

Each of these requested changes has been evaluated to establish its particular features, and related safety and environmental impacts, and the necessary safety conclusions have been drawn.

Proposed Amendment No. 48 supersedes proposed Amendment No. 46 in respect of the item "Rod Misalignment" therein; Amendment No. 46 was submitted by the licensee by letter dated August 7, 1981.

II. Power Distribution Control and Allowable Control Rod Misalignment

A. Introduction

In letters dated November 23, December 8 and December 23, 1981, Wisconsin Public Service (WPS) has proposed (their Amendment 48) revisions to Kewaunee Nuclear Power Plant Technical Specifications. These revisions deal with control rod misalignment and power distribution control Technical Specifications. Both of these subjects have been the focus of much work by the NRC staffs since May 1981.

In 1979 the NRC staff reviewed the LER's and Technical Specification requirements related to the Control Rod Position System for Westinghouse PWRs. Westinghouse had performed safety analyses for control rod misalignment up to 15 inches or 24 steps. The actual misalignment may be 15 inches when an indicated deviation of 7.5 inches exists because the analog control rod position indication system has an uncertainty of 7.5 inches. At that time WPS (Ref. 1) was requested to review their Technical Specifications to ensure that the control rods were required to be maintained within 7.5 inches indicated and that the rod position indication system was verified to be accurate to within 7.5 inches.

WPS responded (Ref. 2) that based on their analysis of a misaligned rod, their operating history and normal mode of operation, their Technical Specifications assured that core power distribution limits would not be exceeded. Their Technical Specifications stated that a rod cluster control assembly could not be misaligned by more than 15 inches without action. They interpreted this as 15 inches indicated.

WPS continued to perform analysis and again (Ref. 3) informed NRC that they believe that the existing Technical Specifications which allowed up to 15 inches indicated misalignment were adequate. The NRC staff did not agree with this.

Since that time there have been many discussions, various interim positions, and a plant visit by NRC staff. WPS's concern in agreeing to a specification limiting them to ± 7.5 inches indicated was a result of a drift problem with the analog control rod position indicating system which made it impossible for them to maintain the ± 7.5 inches indicated for some rods.

B. Evaluation

Revised calibration procedures described in the following SER have been worked out which allow adjustment to compensate for the effects of power ascension. The Technical Specifications as stated in WPS' proposed Amendment 48 allows a ± 7.5 inch indicated misalignment. This is consistent with the Westinghouse analysis and the Standard Technical Specifications. For powers lower than 85 percent, larger misalignments - up to ± 15 inches indicated - are allowed because of the increased margin in peaking factors and greater shutdown margin obtained while operating at lower power levels. The increased flexibility is desired to account for the non-linearity inherent in the rod position indication system and for the effects of temperature and power on the rod position system. The staff concludes that the Technical Specifications relating to allowable control rod misalignment as proposed in their Amendment 48 are acceptable.

The Technical Specification changes dealing with the Reactor Physics Methodology are consistent with the Technical Specifications proposed by Exxon for Westinghouse designed reactors in "Exxon Nuclear Power Distribution Control for Pressurized Water Reactors - Phase 2," XN-NF-77-57(A), May 1981. This is an approved document. The Kewanuee Technical Specifications also include a penalty factor for fuel with burnup greater than 24,000 MWD/MTU as proposed by Exxon. The staff finds these Technical Specification changes acceptable.

C. SUMMARY

The proposed changes in Kewaunee Technical Specifications on control rod misalignment are in conformance with Westinghouse Standard Technical Specifications and are, therefore, acceptable. The proposed changes to the Technical Specifications on the power distribution control strategy are similar to those found acceptable in previous applications and are, therefore, acceptable. The proposed changes will not significantly reduce the safety margin for the Kewaunee Nuclear Power Plant nor adversely affect the health and safety of the public.

References

1. Letter from A. Schwencer (NRC) to E. R. Mathews (WPSC) dated October 29, 1979 concerning control rod position indication systems at Westinghouse PWRs.

2. Letter from E. R. Mathews (WPSC) to A. Schwencer (NRC) dated December 5, 1979 on subject of Rod Misalignment Technical Specifications.

3. Letter from E. R. Mathews (WPSC) to S. A. Varga (NRC) dated May 5, 1981 on subject of Rod Misalignment Technical Specifications.

4. Letter from E. R. Mathews (WPSC) to S. A. Varga (NRC) dated July 8, 1981 on subject of Rod Misalignment Concerns.

5. Letter from E. R. Mathews (WPSC) to S. A. Varga (NRC) dated July 31, 1981 on subject of Rod Misalignment Concerns.

6. Letter from E. R. Mathews (WPSC) to S. A. Varga (NRC) dated August 3, 1981 on subject of Rod Misalignment Concerns.

7. Letter from E. R. Mathews (WPSC) to S. A. Varga (NRC) dated August 7, 1981 on subject of Proposed Amendment 46 to Kewuanee Technical Specifications.

8. Letter from E. R. Mathews (WPSC) to S. A. Varga (NRC) dated August 21, 1981 on subject of FQ Analysis for KNPP Cycle 7.

9. Letter from E. R. Mathews (WPSC) to S. A. Varga (NRC) dated September 2, 1981 on subject of FQ Calculation Methdology.

10. Letter from E. R. Mathews (WPSC) to S. A. Varga (NRC) dated September 21, 1981 on subhect of Rod Misalignment Concerns.

11. Letter from E. R. Mathews (WPSC) to S. A. Varga (NRC) dated October 28, 1981 on subject of Control Rod Misalignment.

12. Letter from E. R. Mathews (WPSC) to S. A. Varga (NRC) dated October 28, 1981 on subject of FQ surveillance.

13. Letter from E. R. Mathews (WPSC) to S. A. Varga (NRC) dated November 16, 1981 on subject of Preliminary Copy of Proposed Amendment 48.

14. Letter from E. R. Mathews (WPSC) to D. G. Eisenhut (NRC) dated November 23, 1981 on subject of Proposed Amendment 48 to the KNPP Technical Specifications.

15. Letter from E. R. Mathews (WPSC) to D. G. Eisenhut (NRC) dated December 8, 1981 on subject of Revisions to Proposed Amendment 48 to the KNPP Technical Specifications.

16. Letter from E. R. Mathews (WPSC) to D. G. Eisenhut (NRC) dated December 23, 1981 on the subject of Revision to Proposed Amendment 48 to the KNPP Technical Specifications.

III. Control Rod Position Indication System Concerns

A. Introduction

Operating experience at Westinghouse (W) PWRs has shown that the analog control rod position instrumentation based upon the Linear Variable Transformer detection method may have inherent characteristics which make it difficult to meet the accuracy requirements assumed by the plant's safety analyses.

In the autumn of 1979, the NRC noted that if one of the detector coils should fail (a single failure) the rod position indication system would be in error by 12 steps (or 7.5 inches, since the coils are spaced 3.75 inches apart, one step being equal to 5/8 inch). In October 1979, the NRC sent generic letters to each W licensee (Reference 1) indicating that, with an uncertainty of 12 steps in the instrumentation, the accident analysis assumption of a control rod misalignment of 24 steps (i.e., 15 inches) could not be assured unless the licensee took action at the point where an indicated deviation of 12 steps occurred. These letters requested each licensee to propose revised Technical Specifications accordingly.

In the fall of 1980, operating experience at another W PWR showed that, even without a failure in the system, the inherent characteristics of the system made the goal of a ± 12 steps accuracy a difficult challenge for this generation of instrumentation.

The Technical Specifications for the Kewaunee plant required that the licensee maintain rod misalignment no greater than 15 inches (i.e., 24 steps). The licensee responded to the NRC original concern with a letter dated December 5, 1979 (Reference 2), in which the licensee stated his intent to show by core physics analysis that an indicated misalignment of 24 steps plus the uncertainty (i.e., 36 steps total) would not violate the core power distribution limits. In Reference 3, the licensee reported the completion of such analyses, with the conclusion that either power peaking factors were maintained within the specified limits or an axial offset or core flux tilt limit was reached. On this basis, the licensee stated that no changes to the Technical Specifications were being proposed.

As shown in the list of References, many formal exchanges of information have occurred between the NRC and the licensee on the matter of Control Rod Position Indication. In addition, the NRC participated in numerous telephone conferences with the licensee, reviewed many draft copies of WPS correspondence, and made a visit to the plant to gain first-hand knowledge of the instrumentation performance capabilities. Separately, the matter of the rod position instrumentation has been discussed several times with Westinghouse; reference 8 is one of the results of these discussions.

B. Background

The rod position detector is a linear variable transformer consisting of primary and secondary coils alternately stacked on a stainless steel cylindrical tube. An extension shaft from the rod drive mechanism extends up into the tube and serves as the variable "core" for the transformer. With a constant a.c. current source (200 mA) applied to the primary windings, the position of the rod drive extension shaft changes the primary to secondary coupling and produces a secondary voltage that is directly related to rod position. The secondary voltage (8.0-12.5 VAC) is sent to an electronic module which converts the a.c. signal into an appropriate d.c. voltage which is sent to the plant process computer. This module contains "Zero" and "Span" adjustments plus an "output voltage" test point (0-3.45 Vdc). A secondary amplifier on the module takes the d.c. output voltage and drives the board-mounted indicator. A built-in set of test points facilitates measurements of the primary voltage of the detector transformers. A test signal generator is provided to adjust the "rod bottom" bistables.

The characteristics of interest are of two general types. First, the channels have non-linearity in the steady-state response. Second, the channels display a time-dependent (transient) response due to thermal effects in the detector assembly.

A typical steady-state calibration curve is an arc-shaped curve, with the indicated position low at the near full-in and near full-out extremities and the indicated position high in the mid-travel region. The steady-state response also depends to some degree upon whether the last rod motion was a withdrawal or insertion. For most rods, but not all, the Zero and Span adjustments allow the steady-state calibration curve to be fitted within the $\pm$12 steps acceptance band. The Zero and Span adjustments are interdependent. Large changes in either of these adjustments can invalidate any previous output voltage-to-position calibration, necessitating a re-calibration by rod full-stroke movement. Once calibrated, however, voltage measurements can be used to determine rod position.

The transient response for the RPI's is typically of the "over shoot" type. That is, if the rod is being pulled out, the RPI indication will show a greater withdrawal and later settle (at thermal equilibrium) back to the steady-state value; if the rod is being inserted, the initial indication is greater insertion than actual. The magnitude of this thermal transient response appears empirically to be insignificant in the region of the lowest one-third of rod travel. However, near the fully withdrawn positions, this transient response at some plants can be as great as 25 steps. The time constant of the thermal recovery toward the steady-state value varies with rod location radially across the core and has values between 10 and 15 minutes. "Settling Times" of 20 to 45 minutes have been observed before steady-state is reached.

While the Rod Position Indicators (RPI's) may not be formally classified as "safety-related", these indications are important to safety. First, FSAR Chapter 15 accident analyses generally presume an instrument accuracy no worse than ±12 steps when evaluating potential rod misalignments. Secondly, the indication that the rods are at the bottom (i.e., "seated") following scram is an important function provided by these channels.

The poor performance of one RPI is a situation of limited concern. However, our on-site review of the situation confirmed that several of the indicators behave generally the same. Our concern in the more generalized case includes not only a possible non-conservative FSAR assumption, but also the potential for operator disregard or distrust of these indications because of a history of accuracy problems.

C. Evaluation

The Technical Specifications (T.S.) for this plant were written before the advent of standard technical specifications. The Kewaunee T.S. (Section 3.10.e) contain a requirement that, if a control rod becomes misaligned from its bank by more than 15 inches, remedial action would be taken. If certain actions were not completed within two hours, reactor power had to be reduced to 85% or less. This T.S. is a functional requirement in that the functional objective is stated but the specific requirements are only implied. For example, the control room indications that would define a 15-inch misalignment are not specified.

The Kewaunee T.S. requires (Section 3.10.f) that the position of a control rod be checked indirectly when an individual rod position indicating channel is out-of-service or "inoperable." However, the T.S. do not specify what constitutes an "inoperable" channel. There have been plant operating conditions where the indicated rod position deviated from the actual rod position by 12 or more steps and the channel was not declared to be inoperable.

By comparison, standard Technical Specifications for Westinghouse plants require: (1) that the rod position indicating instrument for each control rod have an inaccuracy of no greater than ± 12 steps (i.e., 7.5 inches); and (2) that, if an individual rod position indication deviates from the bank demand counter by 12 steps or more, the control rod is declared to be misaligned and action is required.

Similarly, the present Kewaunee T.S. (Section 3.10.i) require certain manual surveillance actions when the automatic Rod Deviation monitor is "inoperable." There is no T.S. requirement specifying what the setpoint for this alarm should be. The setpoint had been 20 steps. The operators would be "alerted" by this alarm but would not necessarily have taken any action until the indicated deviation reached 24 steps (i.e., 15 inches). This practice did not allow for any uncertainty or inaccuracy in the indication.

When the NRC requested the licensee to propose a T.S. limit of a 12-step indicated deviation as a definition of a misaligned rod, the licensee apparently perceived a situation that could restrict plant operations significantly without any safety improvement. The licensee is concerned with reactor safety and would take appropriate corrective action when he believed that a rod is misaligned. However, to define a misaligned rod against instrumentation of such accuracy is a different matter. During our visit to the plant, about four rod position indicators showed values that were 12 steps or more away from the demand counters. Other indications had confirmed that the rods were in fact at the positions shown by the demand counters.

The licensee had proposed to depend upon indirect measurements of rod positions. Clearly, indirect measurements from ex-core neutron detectors, thermocouples, and movable in-core detectors can provide data about core conditions from which some information regarding rod positions can be inferred. However, long-standing policy and practice of the NRC has been to require rod position information to be displayed directly. Therefore, reliance upon indirect measurements and alarms such as axial offset or flux tilt to determine misaligned rod positions is not sufficient.

After discussions with the licensee, a solution that meets the NRC requirements and avoids unduly restricting plant operations has been developed. This solution centers on several points which are discussed below.

1. A primary purpose of rod-misalignment specifications is to avoid flux peaking factors less conservative than assumed for the accident analysis. If such conditions can be recognized and corrective action initiated within a couple hours, the accident analyses are protected to an acceptable degree. That is, a potentially misaligned rod that is undetected for up to an hour is not unacceptable.

2. Previously, the NRC had considered the primary indicator of rod position to be the individual rod position channels; the demand counters had been considered to be of secondary importance. There were several reasons for this approach. One is that there is only one demand counter for each group of several rods and individual rod position is valuable. Another is that the demand counters indicate basically the input to the rod drive control system (i.e., where the rods "are told to go") and the individual position indicators independently show the output of the rod drive control system (i.e., where the rods "actually went").

   However, the operating experience with these individual rod position indicators has been plagued by less-than-desirable performance. The steady state errors and transient indications of this generation of instrumentation are significant. On the other hand, the reliability of the control rod drive system has been quite good. The demand counters almost always show the correct position of the rods and in an accurate and convenient to read manner.

Therefore, based upon this operating experience, the demand counters are now considered the immediate and primary rod position indicators at this plant. When confirmation is needed periodically, the individual rod position channels can be used. Such use must be delayed about 30 minutes to allow the transient behavior to dissipate and must be used with care as discussed further below.

3. The calibration of the individual rod position channels is performed at hot zero-power conditions, since full-stroke rod motion is involved. However, when full power is reached the conditions ambient to the channel detectors (i.e., the coil-stacks above the reactor vessel head) change. These affects vary somewhat radially across the core and at Kewaunee produce shifts in calibration of the rod position channels of three to six steps. The exact values of these shifts must be determined empirically. We are allowing the licensee to make minor corrections to accomodate these shifts in instrument calibration due to power ascension. Technical Specifications have been amended to require that, following any such adjustment, the channel be checked at an intermediate and at a low level to confirm that the overall calibration is not adversely affected by the adjustment.

4. The design of the channel output amplifier that drives the individual rod position meter, the meter itself, and the Rod Deviation alarm (which is generated by the plant process computer) are based implicitly upon the presumption of a linear relationship between the "output voltage" of the channel and actual rod position. Investigation has shown that this relationship is not linear and is actually arc-shaped (as discussed in the "Background" section of this report). The deviation of the arc from a straight line can be 12 steps or more. We are allowing the licensee to make "software corrections" to account for known non-linearity of the channel. These corrections take two forms. First, the plant process computer has been programmed to employ a curve-fitting process in converting the rod position channel output voltage signal into a rod position in steps. Second, when it becomes desirable to determine the position of a rod by manually reading the output voltage of a channel, the voltage vs steps calibration curve may be used. In these ways, the non-linearity of the channels is taken out of the position determination.

With these general improvements, the licensee has developed the following procedures to detect a misaligned control rod:

(a) The Rod Deviation alarm will have a setpoint of 12 steps when reactor power is 85% or greater. When the process computer is available, it provides continuous monitoring of the deviation between the demand counters and the individual rod position indicators. If this alarm sounds and does not clear itself within one hour, the rod will be declared to be misaligned and remedial action will be initiated.

(b) When the process computer is not available, the positions of the rods as indicated by the individual meters will be compared to demand counters by the reactor operator at least every eight-hour shift and following rod motion of greater than 6 inches. If these indications agree within the 12-step limit, no further action is necessary. If these indications deviate by 12 steps or more, the output voltage of the individual channel will be measured manually within two hours. If the rod position, as shown by the voltage measurement and rod calibration curve, deviates from the demand counter by 12 steps or more, the rod will be declared to be misaligned and remedial action will be initiated.

The licensee has now proposed changes in the Technical Specifications that change the 15-inch misalignment requirement to an indicated ±12 steps limit to accomodate uncertainty in the rod position indicating instrumentation. The proposed Bases for the T.S. describe the rod position instrumentation and provide the accuracy limit of 7.5 inches (12 steps) for operability.

Summary

The licensee has developed a better understanding of the capabilities and limitations of the individual control rod position instrumentation. Based upon this understanding, several improvements have been made in corrections for the calibration procedures and in operating techniques. The licensee has therefore reached a position of being able to propose the Technical Specifications changes that were requested without unduly restricting plant operations. Based upon our understanding of the information provided, we conclude that the proposed changes regarding rod position instrumentation are acceptable.

Environmental Consideration

We have determined that the amendment does not authorize a change in effluent types or total amounts nor an increase in power level and will not result in any significant environmental impact. Having made this determination, we have further concluded that the amendment involves an action which is insignificant from the standpoint of environmental impact and, pursuant to 10 CFR §51.5(d)(4), that an environmental impact statement or negative declaration and environmental impact appraisal need not be prepared in connection with the issuance of this amendment.

Conclusion

We have concluded, based on the considerations discussed above, that: (1) because the amendment does not involve a significant increase in the probability or consequences of accidents previously considered and does not involve a significant decrease in a safety margin, the amendment does not involve a significant hazards consideration, (2) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, and (3) such activities will be conducted in compliance with the Commission's regulations and the issuance of this amendment will not be inimical to the common defense and security or to the health and safety of the public.

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Control Rod Position Indication System Concerns
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REFERENCES

1. Letter; A. Schwencer (NRC) to E.R. Matthews (Wisconsin Public Service Co. - WPS), dated October 29, 1979.
2. Letter; E.R. Matthews (WPS) to A. Schwencer (NRC), dated December 5, 1979.
3. Letter; E.R. Matthews (WPS) to S. Varga (NRC), dated May 5, 1981.
4. Letter; E.R. Matthews (WPS) to S. Varga (NRC), dated July 8, 1981.
5. Letter; E.R. Matthews (WPS) to S. Varga (NRC), dated July 31, 1981.
6. Letter; E.R. Matthews (WPS) to S. Varga (NRC), dated August 3, 1981.
7. Letter; E.R. Matthews (WPS) to D. Eisenhut (NRC), dated August 7, 1981.
8. Letter; E.P. Racke, Jr. (Westinghouse) to L.E. Phillips (NRC), dated August 12, 1981.
9. Information provided by licensee during plant visit of September 14, 15, 16, 1981.
10. Letter; E.R. Matthews (WPS) to S. Varga (NRC), dated September 21, 1981.
11. Letter; E.R. Matthews (WPS) to S. Varga (NRC), dated October 28, 1981.
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16. Letter; E.R. Matthews (WPS) to D. Eisenhut (NRC), dated December 23, 1981.
17. Memo; L. Rubenstein (NRC) to T. Novak (NRC), dated February 4, 1982.