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Karl R. Goller, Assistant Director
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Division of Operating Reactors

TECHNICAL ASSISTANCE REQUEST NO. ORB-2 212 - LICENSING AMENDMENT REQUEST DATED JANUARY 26, 1976, REGARDING WEEKLY CONTROL ROD OPERABILITY TESTS

PLANT NAME: Monticello Nuclear Generating Station
DOCKET NO.: 50-263
RESPONSIBLE BRANCH AND PROJECT LEADER: ORB-2, R. Snaider
OPERATIONAL TECHNOLOGY BRANCH INVOLVED: Reactor Safety
REVIEW STATUS: Complete

The Reactor Safety Branch has reviewed the referenced request and recommends that the question of required test frequency of control rod drives be considered as a portion of the ATWS review, not as a separate issue.

A discussion of the evaluation performed by the Reactor Safety Branch is enclosed.

Darrell G. Eisenhut

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Enclosure:
As stated

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CONTROL ROD DRIVE TEST FREQUENCY

The Northern States Power Company, (NSP) has proposed to revise the Monticello Technical Specifications to require that the control rod drives be tested monthly instead of weekly, as is currently required. In order to show the adequacy of monthly testing, NSP calculated the probability of two control rods being inoperable. NSP's analysis was based upon the statistical methods of WASH 1270. The results of NSP's analysis show that for weekly testing the probability of having 2 undetected inoperable control rods when required for insertion is 2.27×10^{-9}. For the monthly testing they propose for Monticello, NSP calculates the corresponding probability to be 4.27×10^{-8}. NSP's analysis appears to be quite non-conservative since it only calculates the probability of failure of two specific rods, whereas there are many pairs of rods whose failure is unacceptable.

Using the binomial probability function the staff (R. Easterling - Applied Statistics Group) has calculated that for weekly testing the probability of having 3 undetected rods fail or have two geometrically close rods fail (one rod at random and one of 20 selective rods (out of 120) which would not allow the core to remain subcritical)) is 2.8×10^{-6}, which is a factor of 1000 higher than the value calculated by NSP. Details of this analysis and other results appear in the Appendix.

The staff analysis is nonconservative since in actuality the system unreliability is apt to be higher than we calculated. That is, the inoperability of a given control rod is not completely independent of all other control rods since all control rods are subjected to the same operating environment, are of the same design, are manufactured at the same facility etc.

The staff is currently developing an ATWS implementation schedule for operating reactors. Since modifications that may be required on Monticello to satisfy ATWS requirements would tend to significantly improve the plant shutdown reliability, this would have an appreciable impact on the required test frequency for the control rod drives. Therefore, the staff recommends that the question of control rod drive test frequency be deferred at this time but be considered as a portion of the staff ATWS evaluation on Monticello.

APPENDIX

ESTIMATION OF CONTROL ROD SYSTEM FAILURE PROBABILITY

Suppose that the probability of failure of any control rod, when challenged, is p. Suppose further that the success or failure of a control rod is independent of the success or failure of any other control rod in the system. With these assumptions, the number of failed control rods, at a time in which they are all challenged, has a binomial probability distribution with parameters n = 121, since there are 121 control rods in the Monticello core, and p. Thus, if the system is regarded as failed when two or more rods fail, the probability of system failure, call it $Q_1(p)$, is given by

$$Q_1(p) = \sum_{i=2}^{121} \binom{121}{i} p^i (1-p)^{121-i}$$

and this expression is approximately equal to 7260 p^2, for small p.

An alternative definition of system failure is that the system is regarded as failed in the case of exactly two rod failures only if given one failure, the other failed rod is among the 20 rods geometrically close to the first. Three or more rod failures also constitutes a system failure whatever the geometric distribution. This definition yields a system failure probability of

$$Q_2(p) = \frac{1}{6} \binom{121}{2} p^2 (1-p)^{119} + \sum_{i=3}^{121} \binom{121}{i} p^i (1-p)^{121-i},$$

which is approximately equal to $Q_1(p)/6$, for small p.

Evaluation of $Q_1(p)$ or $Q_2(p)$ requires a value of p. Under the assumption that time to failure of a control rod has an exponential probability distribution with a mean time to failure of $1/\theta$ years, past experience can be used, as NSP did, to estimate θ. If there are N equally spaced surveillance tests per year of a rod, then, by the methodology of WASH-1270, the failure probability of a rod is given by

$$p \approx \frac{\theta}{2N}.$$

The Monticello experience yields an estimate of θ (actually an upper 95% confidence limit on θ) of .005. Evaluating $Q_1(p)$ and $Q_2(p)$ for $\theta = .005$ and N = 52, 12, and 6 yields the following table.

Surveillance Frequency	N	$Q_1(p)$	$Q_2(p)$
Weekly	52	1.6×10^{-5}	2.8×10^{-6}
Monthly	12	3.1×10^{-4}	5.3×10^{-5}
BiMonthly	6	1.2×10^{-3}	2.2×10^{-4}