October 25, 2000

MEMORANDUM TO: Glenn M. Tracy, Chief
Operator Licensing, Human Performance, and Plant Support Branch
Division of Inspection Program Management
Office of Nuclear Reactor Regulation

FROM: Mark A. Cunningham, Chief /RA/
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SUBJECT: RISK ASSESSMENT INPUT TO FATIGUE ACTION PLAN

In response to a request by David Desaulniers of the Operator Licensing, Human Performance and Plant Support Branch in the Office of Nuclear Reactor Regulation, the Probabilistic Risk Analysis Branch in the Office of Nuclear Regulatory Research has examined risk-related issues concerning the effects of personnel fatigue on nuclear power plant safety. Attached is a set of proposed inputs to the Fatigue Action Plan.

Please feel free to direct any questions you may have on this topic to Eric Thornsbury at 415-6216 or Nathan Siu at 415-6380.

Attachments: 1. Input to Fatigue Action Plan

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Input to Fatigue Action Plan

In a probabilistic risk assessment (PRA) framework, the risk significance of fatigue effects can, in principle, be assessed through two classes of PRA model parameters: the human error probabilities (HEPs), which deal largely but not exclusively with control room actions, and hardware-related parameters (e.g., initiating event rates and component failure probabilities, both of which can be affected by testing and maintenance practices). To date, such an assessment has not been done, partly because of technical difficulties discussed below. However, since available empirical evidence indicates that fatigue can have a strong impact on human performance, it follows that fatigue could have a significant impact on the HEPs. Furthermore, sensitivity analyses using PRA models show that global changes in HEPs can significantly affect the calculated core damage frequency (CDF). While several technical issues still require resolution, it appears that the effects of fatigue could decrease plant safety.

Data suggest that fatigue, as generated from extended work hours or circadian rhythms, has significant effects on the likelihood of human error. In some cases, increases in error rates can be quite large (e.g., on the order of a factor of 10). It should be cautioned that determining the quantitative increase in the HEPs used in nuclear power plant PRAs is not straightforward. Factors that need to be considered include the portion of time fatigue effects are operative, the nature of the tasks on which the data is based, differences in maintenance and control room activities, and the possibility that all HEPs are not universally affected. The staff is not aware of any PRA study that has considered the effects of fatigue.

To assess the sensitivity of CDF to changes in HEP values, three studies were briefly reviewed by RES: 1) NUREG/CR-5319, *Risk Sensitivity to Human Error*; 2) NUREG/CR-5527, *Risk Sensitivity to Human Error in the La Salle PRA*; and 3) BNL L-117(2), *A Comparison of the Sensitivity of Risk to Human Errors in the Oconee and La Salle PRAs*. The review showed that changes in HEPs of a factor of five result in an increase in CDF of a factor of between four and 33. In addition, it showed that a factor of two change in all HEPs interpolates to a ΔCDF of between 1E-5 and 1E-4. These findings demonstrate that relatively small changes in HEPs can be significant. These results broadly agree with work done by the Office of Nuclear Reactor Regulation using Standardized Plant Analysis Risk (SPAR) models.

The preceding discussion suggests that the effects of fatigue could, under certain conditions, be risk significant. If risk insights are needed as part of continued fatigue work, a number of conditions would have to be addressed. In particular, the effect of fatigue on HEPs for different actions modeled in the PRAs would need to be determined. The potential credit for fatigue management strategies (including both current licensee practices and possible additions), situations where fatigue effects may be more prevalent (e.g., outage conditions), and the effects of fatigue on other PRA parameters (other than the HEPs) also would need to be assessed.