October 13, 2001

MEMORANDUM TO: Gary M. Holahan, Director
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Office of Nuclear Reactor Regulation

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FROM: Scott F. Newberry, Director /RA/
Division of Risk Analysis and Applications
Office of Nuclear Regulatory Research

SUBJECT: NUREG/CR-5632, "INCORPORATING AGING EFFECTS INTO PROBABILISTIC RISK ASSESSMENT—A FEASIBILITY STUDY UTILIZING RELIABILITY PHYSICS MODELS"

Work recently completed at INEEL, which was sponsored by the Division of Risk Analysis and Applications, documents a feasibility assessment for a method of estimating the effects of the aging of structures, systems, and components (SSCs) on the public risk from nuclear reactor accidents. (The subject report is attached.) The method combines data on the aging of SSCs with reliability physics models, and incorporates the resulting estimates of time dependent failure probabilities of the SCCs directly into a PRA. The need for combining reliability physics models with data is a consequence of the limited data available on the aging of some SSCs.

Given its role as a feasibility study, the report limited itself to consideration of a single aging mechanism, that of flow accelerated corrosion (FAC), and simplified the problem by omitting the effects of inspection. The particular reliability physics model used was a load-capacity model; failure occurs when the load exceeds the capacity. Two cases were considered. In the first case, the piping in the main feedwater system at Surry was subject to FAC. The second case was the somewhat artificial case of a pre-heater auxiliary feedwater system at Surry (Surry does not use such a pre-heater), where the pre-heater piping was subject to FAC. The effects of SSC aging on the core damage frequency were small, for the cases examined. The report treated both epistemic and aleatory uncertainty. In this study, the epistemic, or state-of-knowledge, uncertainties are associated with the uncertainties in material properties. The aleatory uncertainties are associated, in this study, with the random nature of the occurrence of initiating events. The PRA calculations were limited to internal events, to the full power mode of operation, and to estimates of the core damage frequency; no estimate of the large early release frequency was given. The work performed shows the feasibility of the method.

Another result of the study was the importance of separating aleatory and epistemic uncertainty. When steady state stresses are considered, the uncertainties are very largely epistemic. That is to say, if there were no state of knowledge uncertainty, the time of failure of the pipe could be predicted almost exactly. This means that there are limitations on the use of a failure rate model for estimating the effects of aging on the failure probability of an SSC.

The understanding of the risk implications of the aging of SSCs helps the NRC in its goals of maintaining and improving safety without placing an unnecessary burden on the licensees. This study is a step in the direction of making our understanding of these risk implications more quantitative and realistic, and improving our ability to make risk-informed decisions in matters involving the aging of SSCs. The inclusion of the aging of SSCs in PRA could be a valuable additional means for determining the most effective means of controlling the risk throughout the current reactor licensing term, and throughout the period of extended operation for those nuclear power plants whose license has been, or will be, renewed.

There are a number of possible followup research topics. These include assessing additional aging mechanisms beyond FAC, assessing the effect of inspection and external event risks. Recognizing that applications of such reliability physics modeling requires considerable resources, part of our future work in FY02 and FY03 will address how to focus such applications on the most important aging phenomena and SSCs.

Extensions of the work in directions other than that of structural reliability are also possible. For example, the development of reliability physics models for cable aging could result in improved estimates of the failure probabilities of cables; these improved estimates of the failure probabilities would improve our estimates of the effect of cable aging on the risk from nuclear power plant accidents. We also intend to explore this in FY02 and FY03.

Please address comments to Arthur Buslik, 301-415-6184.

Attachment: As stated

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