Isolation Condenser Executive Summary

This report presents a performance evaluation of the isolation condenser system (IC) at the five U.S. commercial boiling water reactors (BWRs) that have the system. The study was based on the operating experience from 1987 through 1993, as reported in Licensee Event Reports (LERs) and monthly nuclear power plant operating reports. The objectives of the study were: (1) To estimate system unreliability based on operational data, and to compare the results with the assumptions, models, and data used in Probabilistic Risk Assessments/Individual Plant Examinations (PRA/IPEs), and (2) review the data from an engineering perspective to determine the factors affecting system unreliability, and provide an analysis of the trends and patterns seen in the IC system operational data.

The reliability of the system or train to be assessed was based on the ability of the system to perform its risk-significant function under conditions that best represent those that would be expected under accident conditions. Data from unplanned demands, as a result of transient response, and from full system functional tests were used to estimate the reliability of the system. Data from component failures that did not result in a loss of reactor core cooling function of the system or train, or from tests of only portions of the system were not used to estimate reliability.

IC train unreliabilities were estimated using a fault tree model to associate fault event occurrences with broadly defined failure modes such as failure to operate or failure to provide makeup. The failure probabilities for the individual failure modes were calculated by reviewing the failure information, categorizing each failure, by failure mode and then estimating the corresponding number of demands (both success and failures). IC train and component failure rates were also extracted from PRA/IPEs. These were then combined, consistent with the quantification performed using the operating experience data. The resulting failure mode probabilities were then compared to the system level unreliability estimates and failure mode probabilities calculated for this study. The following is a summary of the major findings.

The IC train unreliability (including recovery), based on operational experience data, is 0.02. The failure to operate failure-mode of the IC train and failure to provide makeup water to the isolation condenser, contributed equally to the overall unreliability. The recovery probabilities associated with these operational modes of the IC train are high, but have very broad uncertainty. With only one or two opportunities, the current operational data give little evidence to support a lower failure to recover probability. More opportunities are needed in order to reduce the uncertainty associated with the failure to recover estimates.

The recovered and non-recovered train unreliability estimates differ by a factor of five. The difference is primarily attributable to the spurious isolations of the IC train as observed in the unplanned demands. All the failures observed for the IC train failing to operate were caused by spurious isolation of the IC train.

The average of the estimates of IC train unreliability based on information contained in the PRA/IPEs was generally about a factor of 1.5 lower than the estimate of the mean probability based on operational experience data. All of the PRA/IPE estimates of IC train unreliability are within the uncertainty interval based on the operational experience data. The average of the PRA/IPE values of IC train unreliability is approximately 1.3E-2 per demand.

The PRA/IPEs show that the condensate isolation valve failing to open as the important contributor to IC train unavailability. However, this contrasts with the calculations based on operational data, which show the effect of this type of failure was not as important to IC train unreliability as the spurious isolations of the IC train. Figure ES-1 shows the train unreliabilities and comparisons to the PRA/IPEs.

The probability of maintenance out of service was not estimated in this report. The operating experience is sparse and a lack of maintenance out-of-service failures (i.e., no failures in 23 demands)

relative to other failure modes does not support postulating this particular failure mode at this time. Based on PRA/IPE information, maintenance accounts for approximately 5% of the total unreliability of the IC train.

No statistically significant trends in IC train failure and unplanned demand frequencies or unreliability by calendar year were observed in the operational experience data. Further, IC train unreliability was analyzed against low-power license date for the plants to determine if unreliability was being affected by plant age. No trends were observed in the low-power license date evaluation. The results of the individual trending analyses are provided in Figures ES-2 through ES-5.

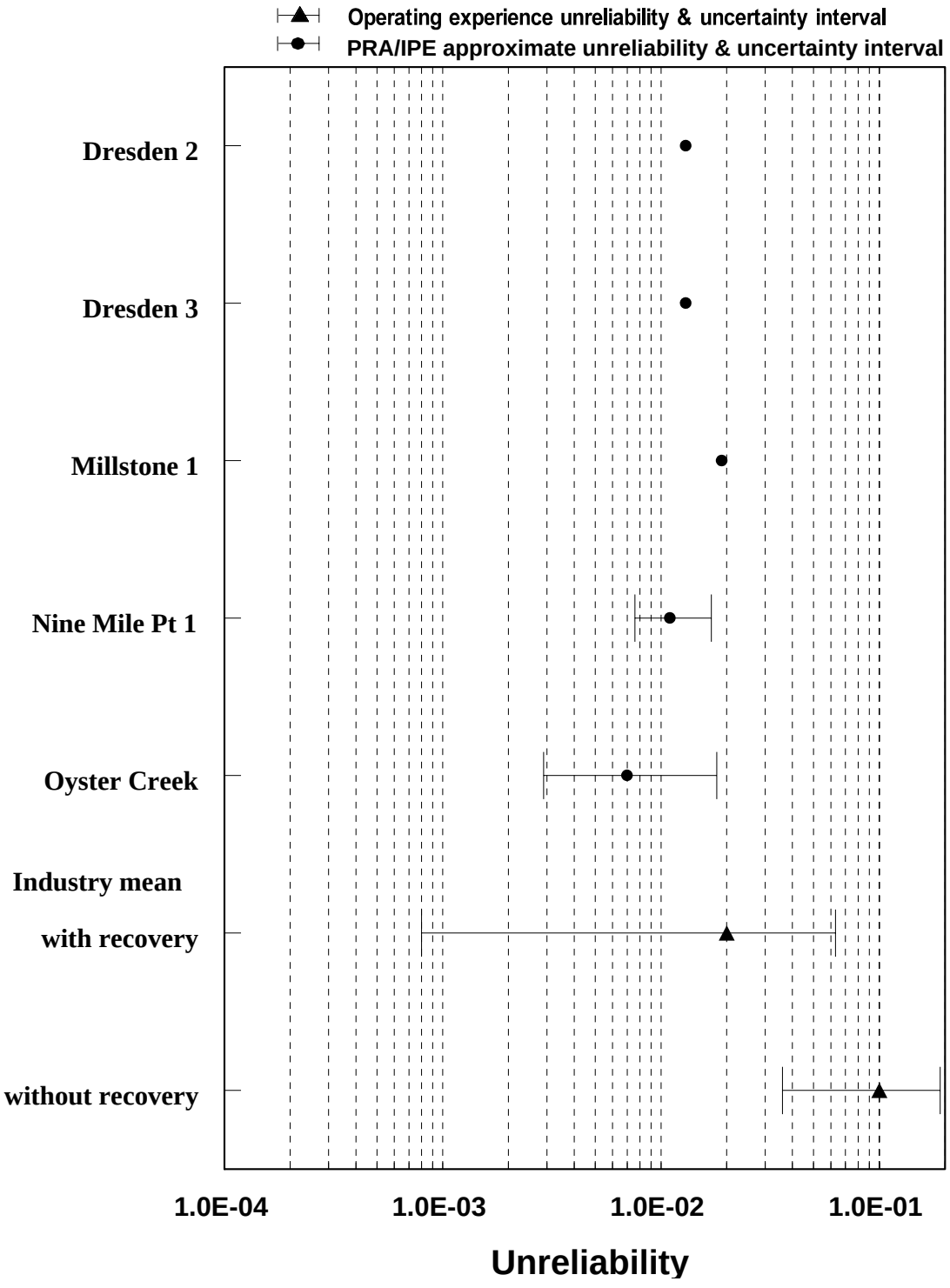

Figure ES-1. Plot of IC train unreliabilities approximated from PRA/IPE information and estimates of IC train unreliability (with and without recovery) calculated from the operational experience data. (For some plants the information documented in the PRA/IPEs was insufficient to generate uncertainty intervals.)

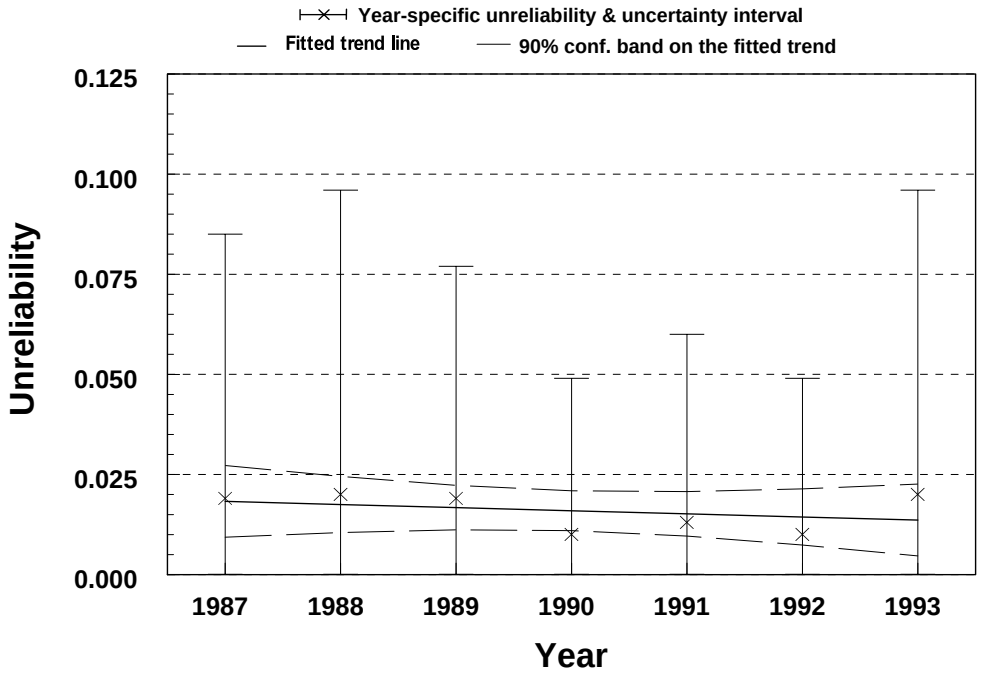

Figure ES-2. IC train unreliability by calendar year, based on a constrained noninformative prior and annual data. The plotted trend is not statistically significant (P-value = 0.43).

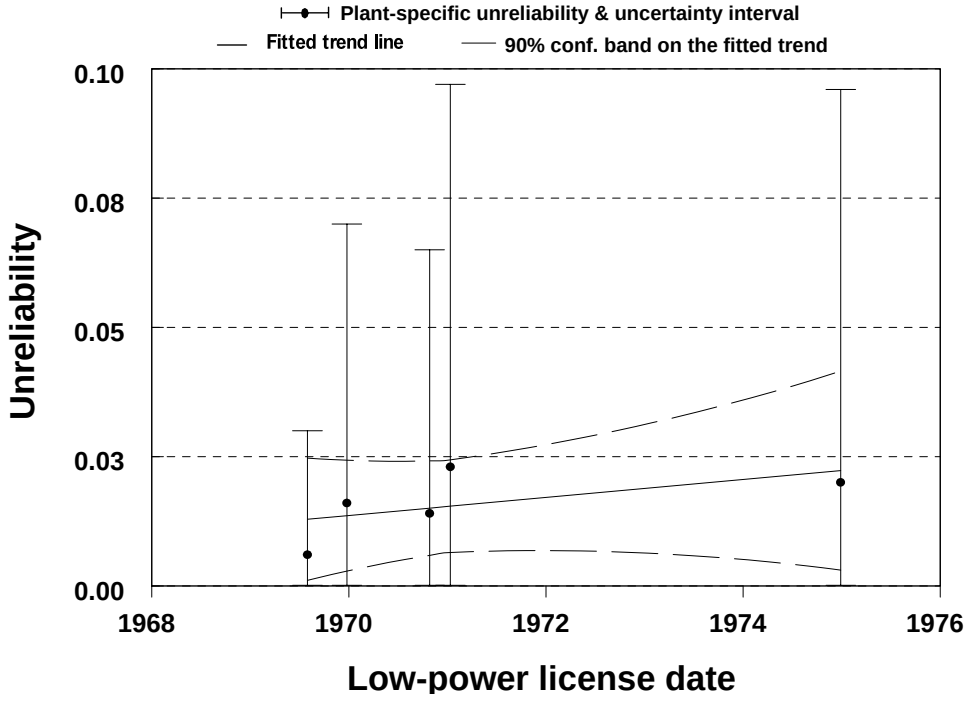

Figure ES-3. Plant-specific IC train unreliabilities based on constrained noninformative prior distributions, which include recovery actions plotted against low-power license dates. The trend is not statistically significant (P-value = 0.30).

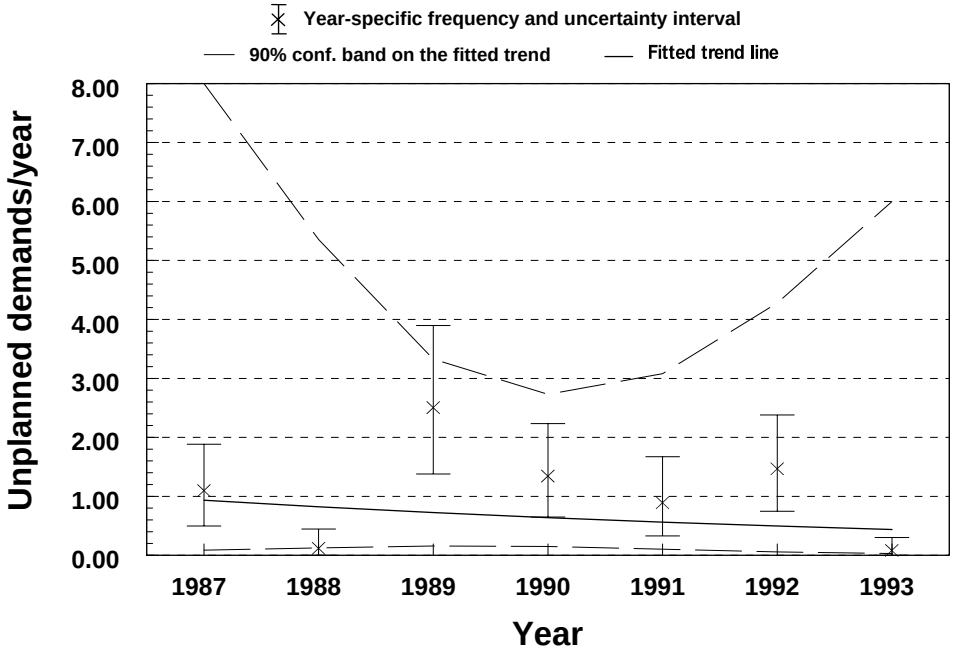

Figure ES-4. IC train unplanned demands per train operational year, with 90% uncertainty intervals and confidence band on the fitted trend. The trend is not statistically significant (P-value = 0.64).

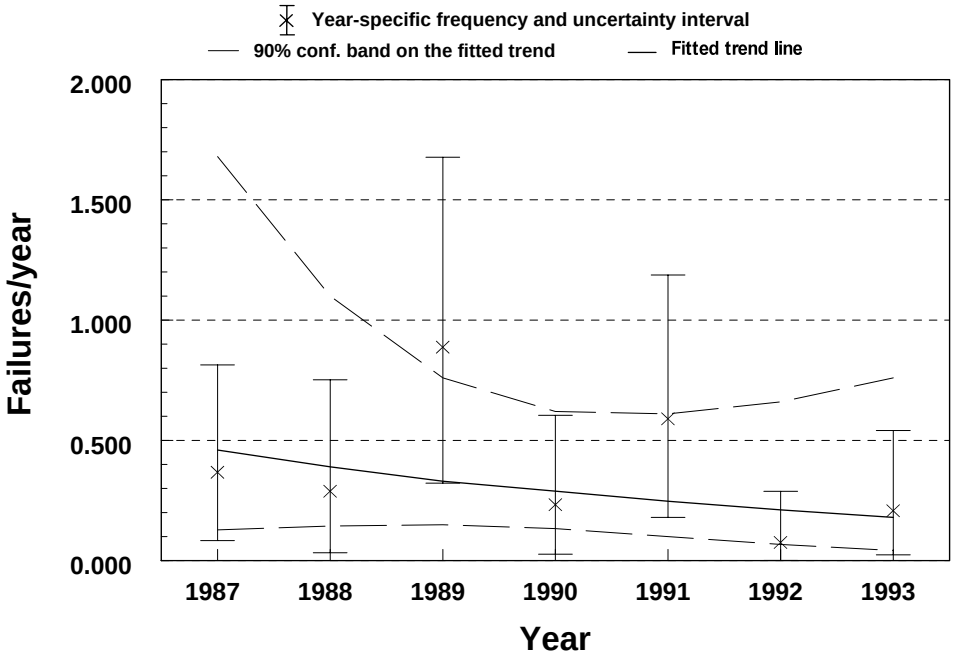

Figure ES-5. IC train failures per train operational year, with 90% uncertainty intervals and confidence band on the fitted trend. The trend is not statistically significant (P-value = 0.30).