Rates of Initiating Events at U.S. Nuclear Power Plants 1988–2003

This report presents an analysis of initiating event frequencies at United States (U.S.) nuclear power plants. The evaluation is based on the operating experience from 1988 through 2003, as reported in Licensee Event Reports (LERs). This is the latest update to NUREG/CR 5750.

1 LATEST FREQUENCIES AND TRENDS

1.1 Selected Frequencies

This report displays occurrence rates for the categories of initiating events that contribute to the NRC's Industry Trend monitoring program. Sixteen initiating event groupings are trended and displayed. BWR and PWR stuck open safety/relief valves are plotted separately because the occurrence rates differ significantly between the two plant types. Each figure is annotated with the p-value.

For each of these indicators, particular starting years have been identified for baseline periods during which the indicator frequencies are approximately constant. In the graphs, these baseline periods have been marked with a mean, upper, and lower bounds for the approximately constant occurrence rates. As in the NRC's Fire Events operating experience study (RES/OERAB/S01-01, V. 1), the maximum likelihood estimate (the total number of events divided by the total number of reactor critical years in its baseline period) has been taken as the mean for each occurrence rate in its baseline period. The constrained noninformative prior distribution was selected to model year-to-year variation around the mean for each indicator. This distribution choice maximizes the uncertainty in the rate. Specifically, the bounds are calculated as 5th and 95th percentiles of a gamma distribution with parameters 0.5 and $1/(2\lambda_0)$.

For five of the initiating event groupings, few occurrences have been observed and the baseline period is the entire study period. For these initiating event groupings, the yearly data are shown along with the horizontal mean and bounds. In many cases, the lower bound is too close to zero to show on the plots. By convention, no trend lines are shown on these plots because the fitted trend is essentially constant (p-value > 0.2) for these initiating event groupings.

For the remaining initiating event groupings, a single trend line is plotted to show the historical performance of the indicator for the entire study period. The p-value in the lower left corner shows whether this long-term trend is statistically significant[1].

1. Statistically significant is defined in terms of the 'p-value.' A p-value is a probability indicating whether to accept or reject the null hypothesis that there is no trend in the data. P-values of less than or equal to 0.05 indicate that we are 95% confident that there is a trend in the data (reject the null hypothesis of no trend.) By convention, we use the "Michelin Guide" scale: p-value < 0.05 (statistically significant), p-value < 0.01 (highly statistically significant); p-value < 0.001 (extremely statistically significant).

For the indicators with baseline periods shorter than the entire study period, trend evaluations were performed separately for the baseline period. None of these trends had p-values as low as 0.05. The hypothesis of variation around a constant occurrence rate is accepted for these indicators, and no trend lines are shown for these baseline periods.

The following table lists the indicators, overall data, and horizontal bounds used in the plots.

Table 1. Initiating events used in the enhanced performance indicator program.

Initiating event functional impact category	Figure	Total Number of events	Total Reactor critical years	Baseline period starting year (FY)	5% Lower Uncertainty Bound	Mean Frequency	95% Upper Uncertainty Bound
Loss of Offsite Power	Figure 1	54	1369.19	1997	1.00E-04	1.59E-02	6.12E-02
Loss of vital AC bus	Figure 2	42	1369.19	1988	1.00E-04	2.88E-02	1.11E-01
Loss of vital DC bus	Figure 3	3	1369.19	1988	1.00E-05	2.54E-03	9.75E-03
Small/very small LOCA	Figure 4	5	1369.19	1988	2.00E-05	4.23E-03	1.63E-02
Loss of heat sink	Figure 5	245	1369.19	1995	5.00E-04	1.28E-01	4.92E-01
Loss of feedwater	Figure 6	181	1369.19	1993	4.00E-04	1.02E-01	3.91E-01
General transients	Figure 7	2050	1369.19	1998	3.20E-03	8.09E-01	3.11E+00
BWR loss of instrument air	Figure 8	19	444.61	1994	0.00E+00	8.60E-03	3.32E-02
BWR Stuck Open SRV	Figure 9	13	444.61	1993	1.00E-04	1.94E-02	7.44E-02
BWR loss of heat sink	Figure 10	147	444.61	1996	7.00E-04	1.88E-01	7.20E-01
BWR general transients	Figure 11	678	444.61	1997	3.50E-03	8.99E-01	3.45E+00
PWR loss of instrument air	Figure 12	17	924.58	1990	0.00E+00	1.15E-02	4.42E-02
PWR Steam Generator Tube Rupture	Figure 13	3	924.58	1988	1.00E-05	3.75E-03	1.44E-02
PWR Stuck Open SRV	Figure 14	2	924.58	1988	0.00E+00	2.50E-03	9.60E-03
PWR loss of heat sink	Figure 15	98	924.58	1991	4.00E-04	9.67E-02	3.71E-01
PWR general transients	Figure 16	1372	924.58	1998	3.00E-03	7.62E-01	2.93E+00

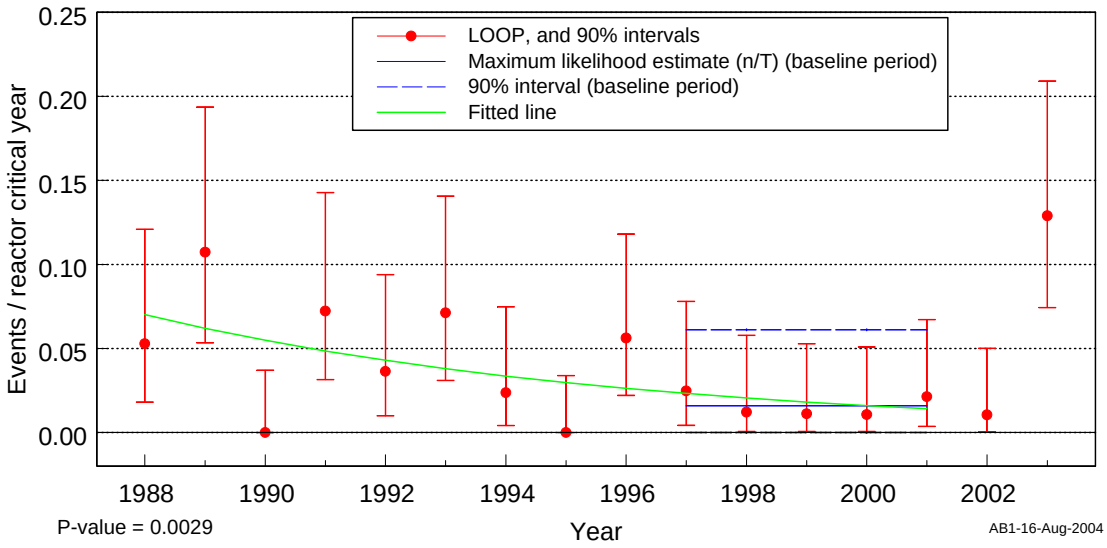

Figure 1. Frequency of initiating events with a loss of off-site power.

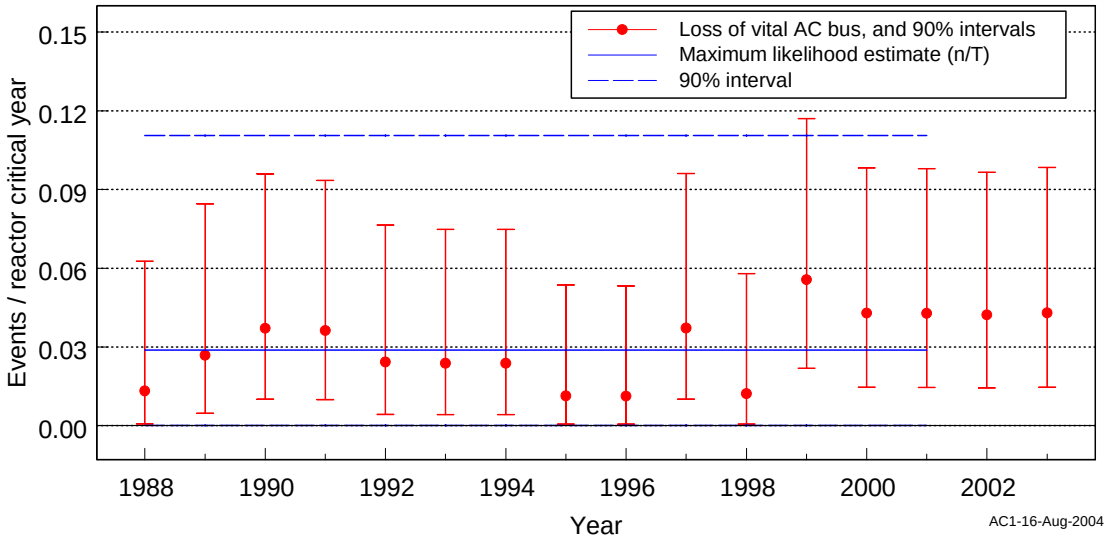

Figure 2. Frequency of initiating events with loss of vital AC bus.

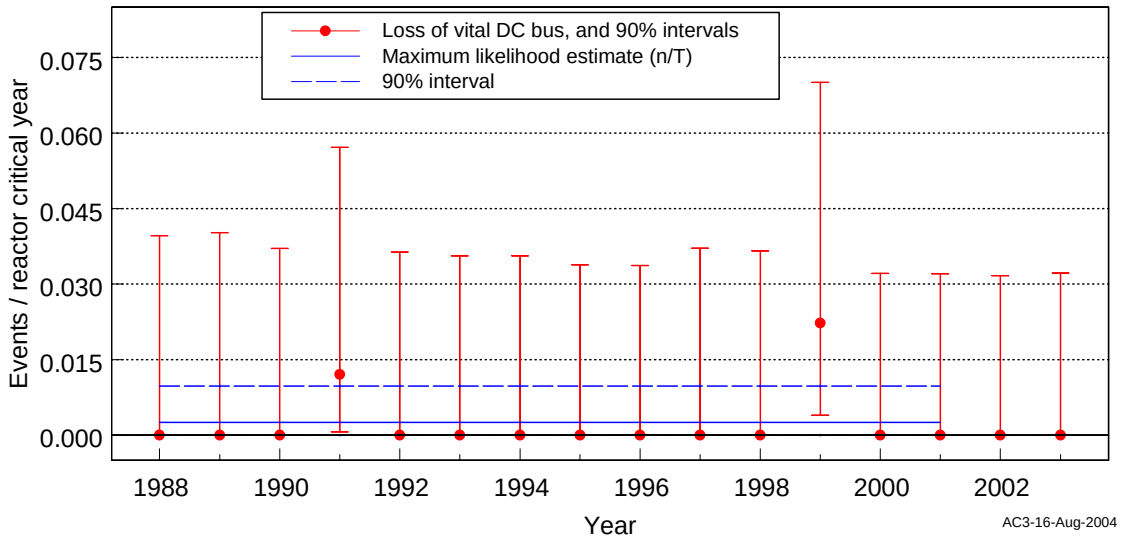

Figure 3. Frequency of initiating events with loss of vital DC bus.

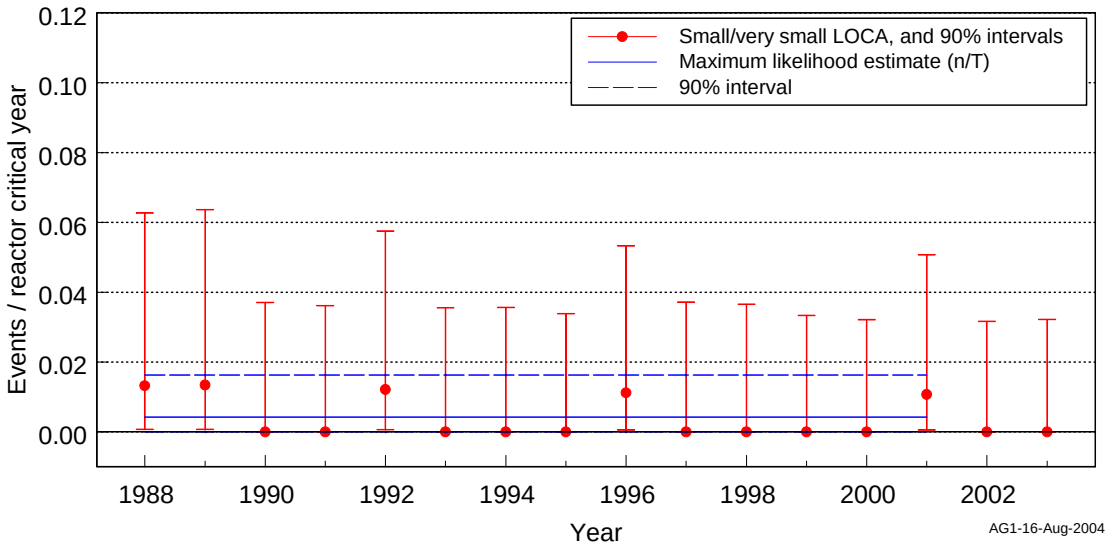

Figure 4. Frequency of initiating events with small/very small loss of coolant accident.

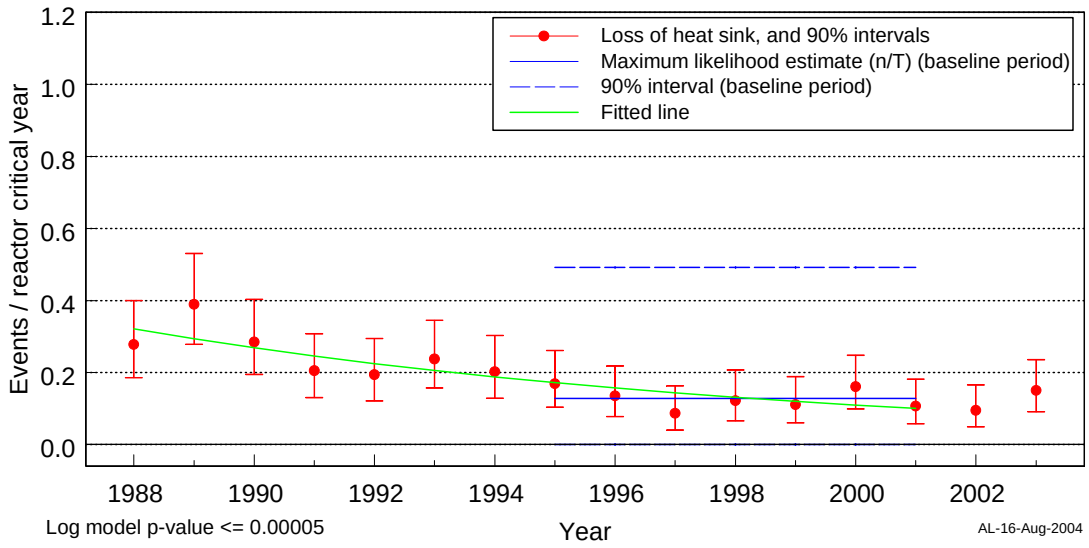

Figure 5. Frequency of initiating events with loss of heat sink.

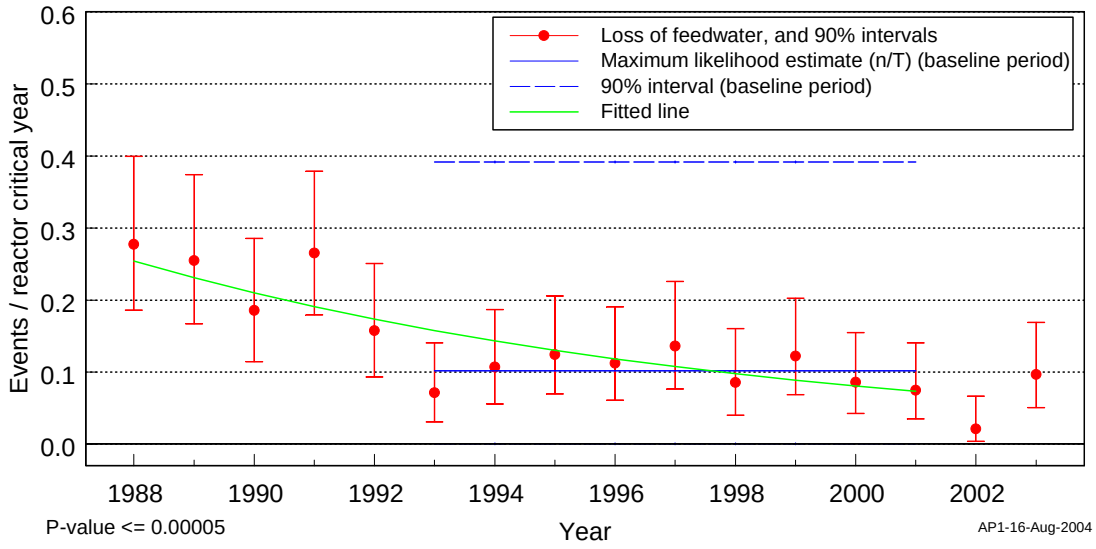

Figure 6. Frequency of initiating events with loss of feedwater.

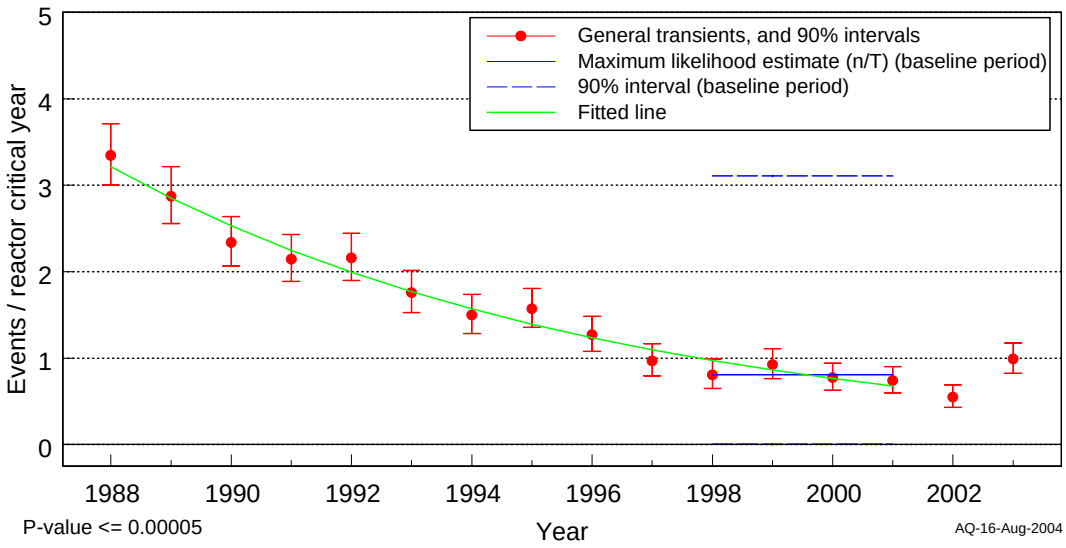

Figure 7. Frequency of initiating events with general transients.

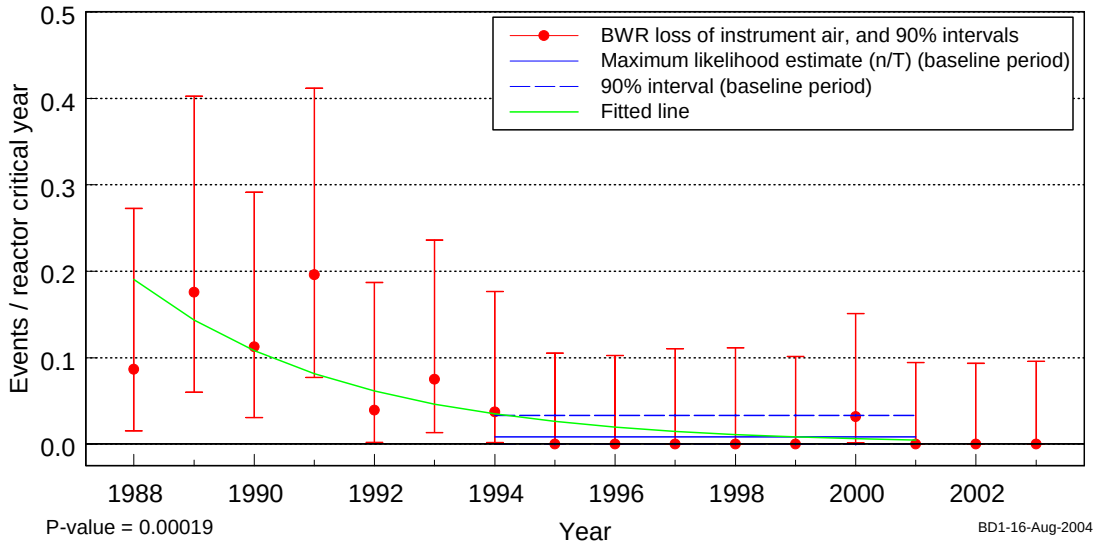

Figure 8. Frequency of BWR initiating events with loss of instrument air.

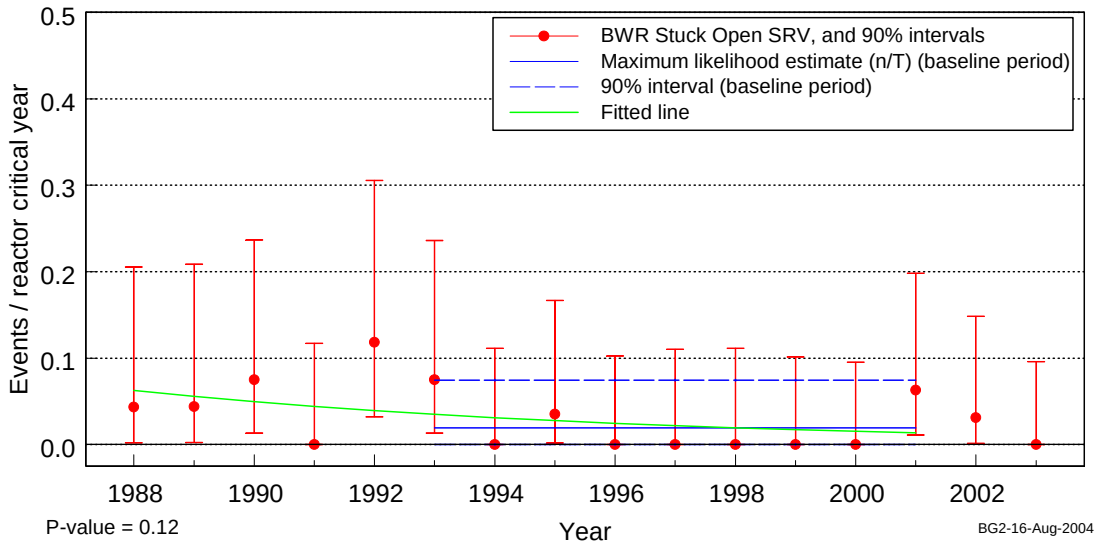

Figure 9. Frequency of BWR initiating events with stuck open safety relief valve.

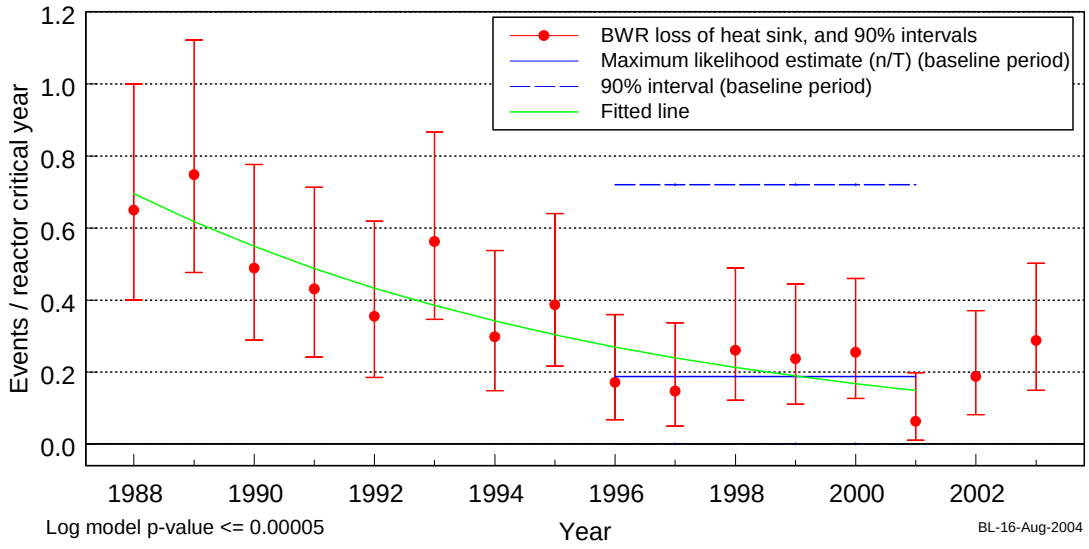

Figure 10. Frequency of BWR initiating events with loss of heat sink.

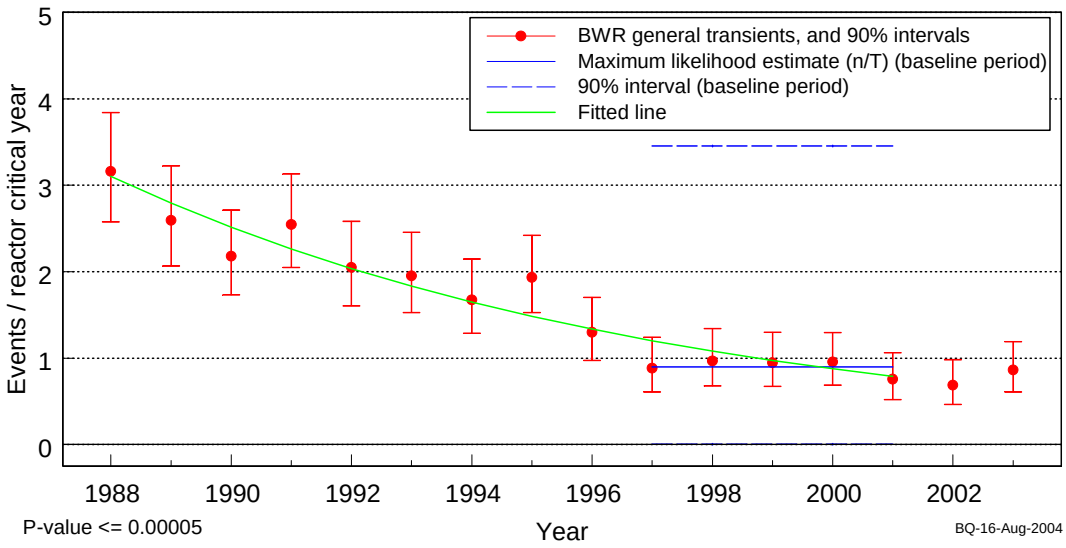

Figure 11. Frequency of BWR initiating events with general transients.

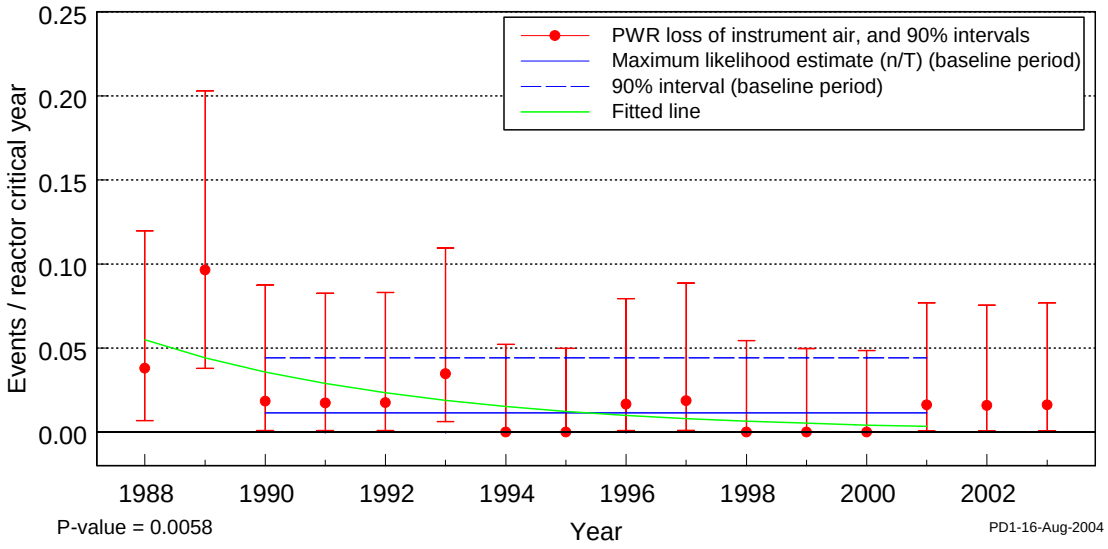

Figure 12. Frequency of PWR initiating events with loss of instrument air.

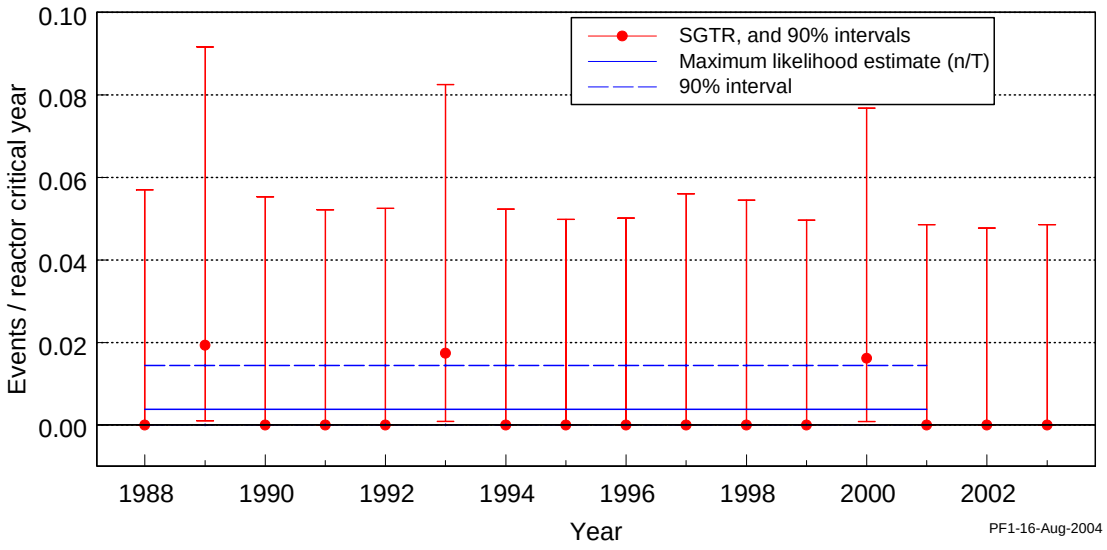

Figure 13. Frequency of PWR initiating events with steam generator tube rupture.

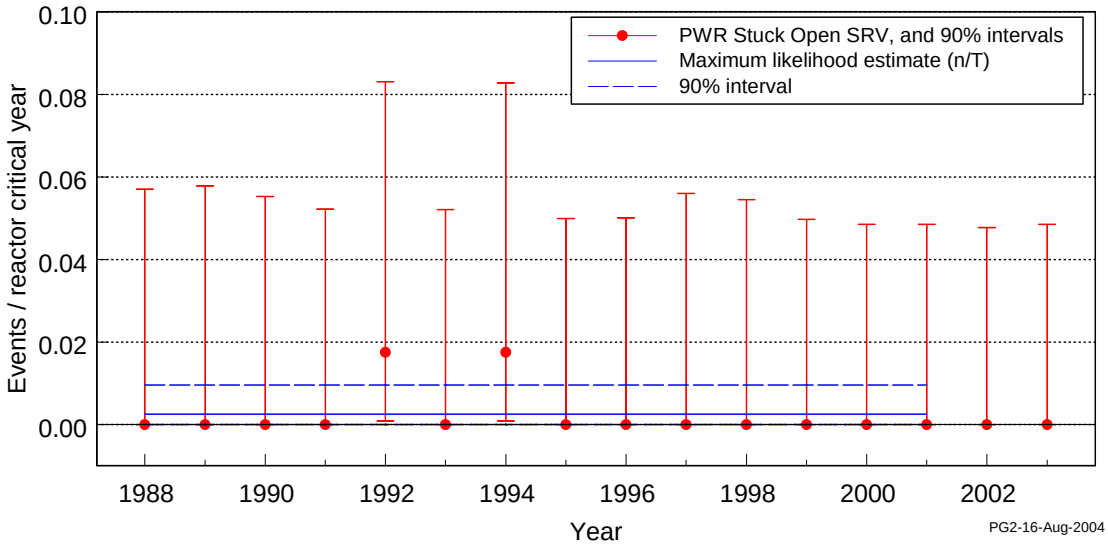

Figure 14. Frequency of PWR initiating events with stuck open safety relief valve.

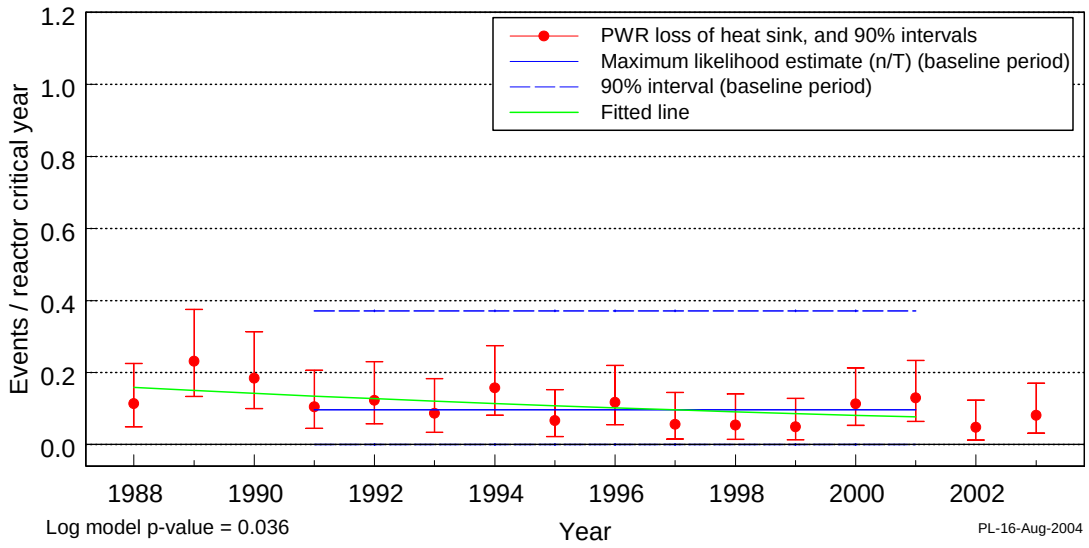

Figure 15. Frequency of PWR initiating events with loss of heat sink.

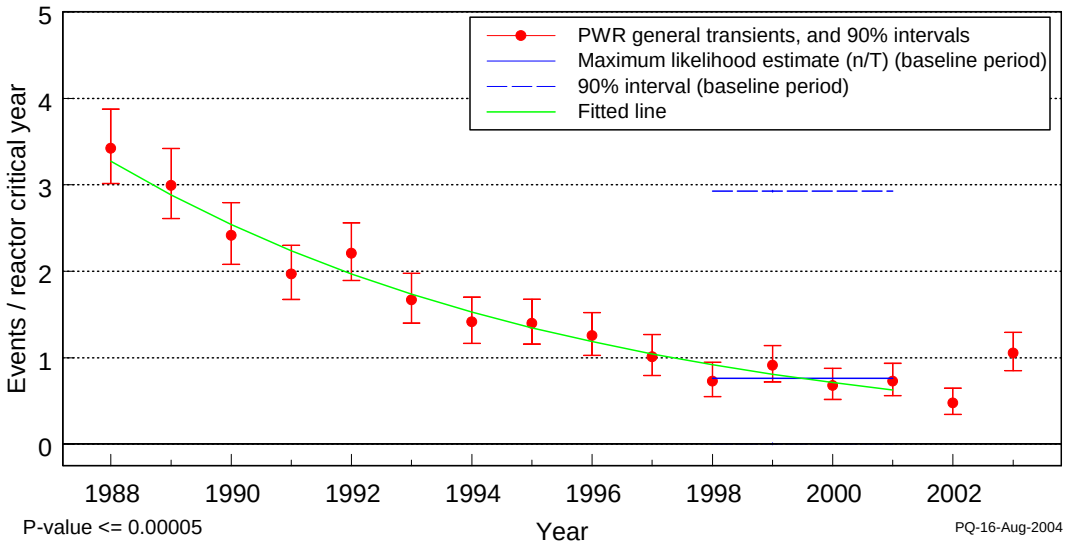

Figure 16. Frequency of PWR initiating events with general transients.