Rates of Initiating Events at U.S. Nuclear Power Plants 1988–2002

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 2002, 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. BWR and PWR stuck open safety/relief valves are plotted separately because the occurrence rates differ significantly between the two plant types. Sixteen initiating event groupings are trended and displayed. Each figure is annotated with the p-value[1].

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. No trend lines show on these plots because no statistically significant trends exist 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. When a p-value is less than 0.05, the trend is likely to represent more than mere random variation.

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

1. A p-value is a probability, with a value between zero and one, which is a measure of statistical significance. The smaller the p-value, the greater the significance. A p-value of less than 0.05 is generally considered statistically significant.

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	Baseline period starting year (FY)	Number of events	Reactor critical years	5% Lower Uncertainty Bound	Mean Frequency	95% Upper Uncertainty Bound
Loss of Offsite Power	Figure 1	1997	8	534.1	0.0001	0.0150	0.0575
Loss of vital AC bus	Figure 2	1988	38	1277.0	0.0001	0.0298	0.1143
Loss of vital DC bus	Figure 3	1988	3	1277.0	0.000009	0.0023	0.009025
Small/very small LOCA	Figure 4	1988	5	1277.0	0.00002	0.0039	0.01504
Loss of heat sink	Figure 5	1995	88	711.8	0.0005	0.1236	0.4749
Loss of feedwater	Figure 6	1993	82	880.1	0.0004	0.0932	0.3579
General transients	Figure 7	1998	341	453.4	0.0030	0.7521	2.8892
BWR loss of instrument air	Figure 8	1994	2	263.5	0.0000	0.0076	0.0292
BWR Stuck Open SRV	Figure 9	1993	6	290.1	0.0001	0.0207	0.0794
BWR loss of heat sink	Figure 10	1996	39	208.2	0.0007	0.1874	0.7197
BWR general transients	Figure 11	1997	153	178.9	0.0034	0.8555	3.2862
PWR loss of instrument air	Figure 12	1990	9	758.9	0.0000	0.0119	0.0456
PWR Steam Generator Tube Rupture	Figure 13	1988	3	863.4	0.00001	0.0034	0.01335
PWR Stuck Open SRV	Figure 14	1988	2	863.4	0.0000	0.0023	0.0089
PWR loss of heat sink	Figure 15	1991	65	704.7	0.0004	0.0922	0.3543
PWR general transients	Figure 16	1998	212	301.7	0.0028	0.7026	2.6991

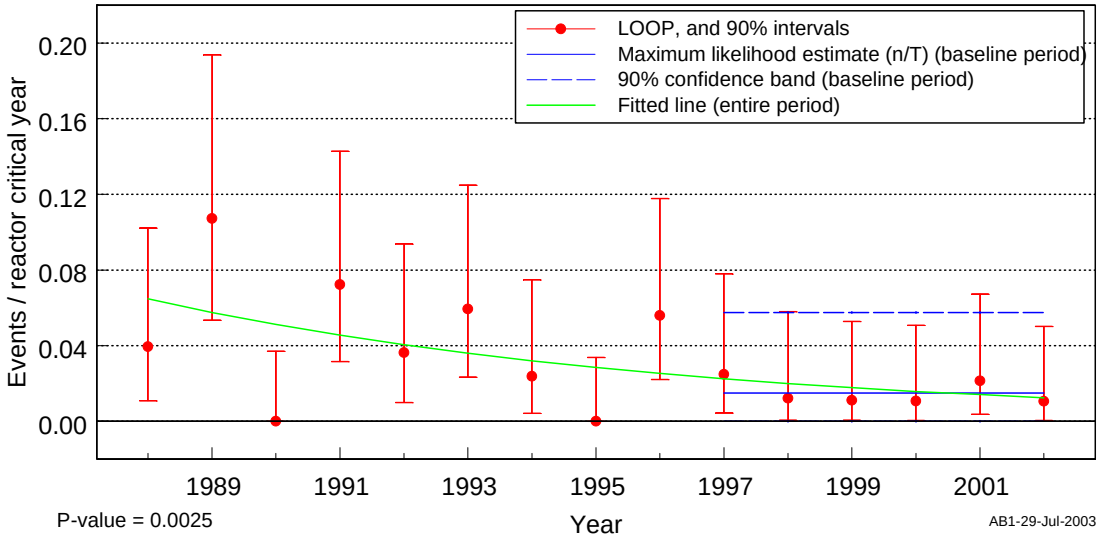

Figure 1. Frequency of initiating events with a loss of off-site power.

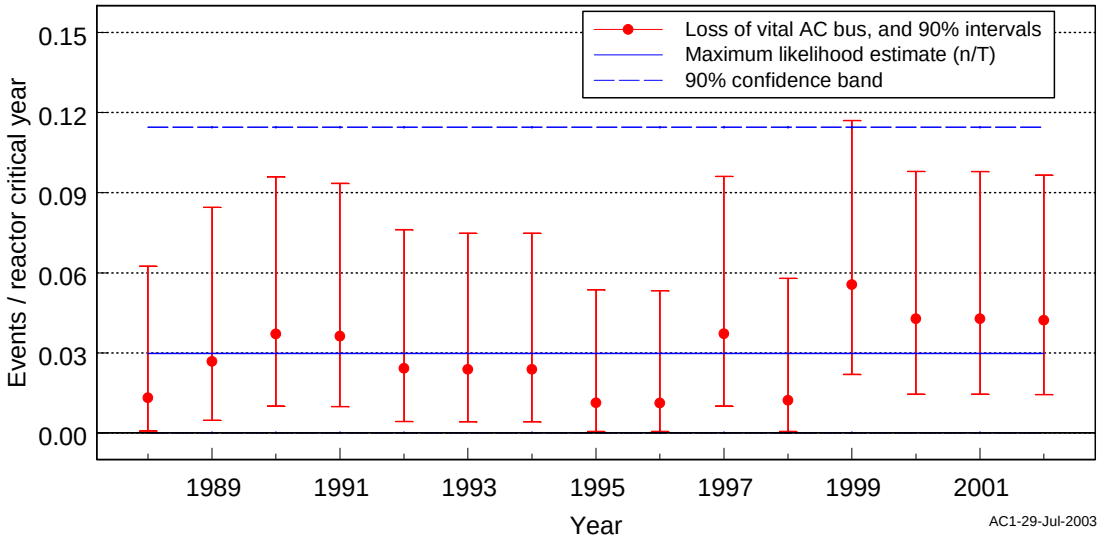

Figure 2. Frequency of initiating events with loss of vital AC bus.

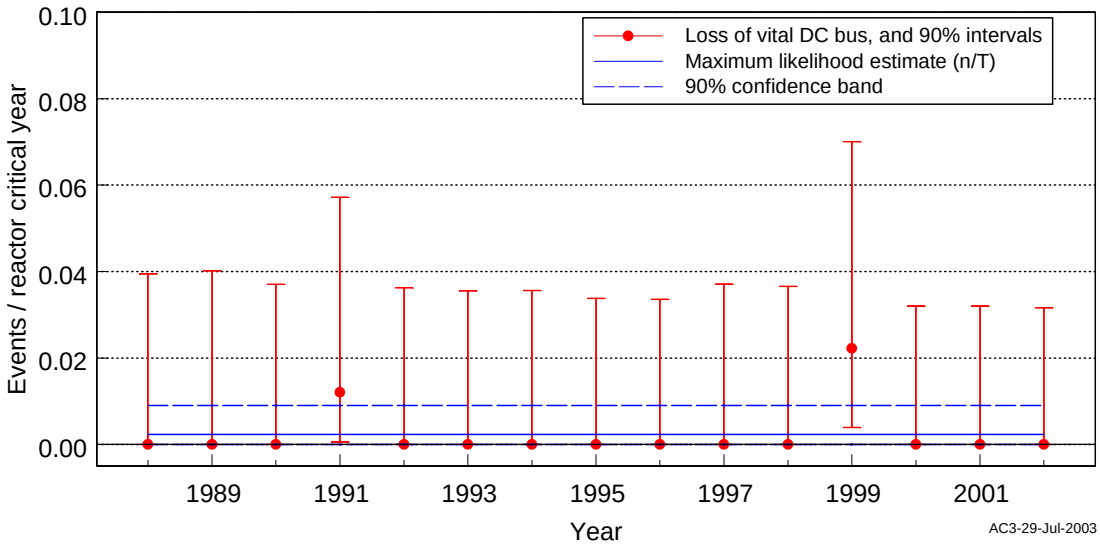

Figure 3. Frequency of initiating events with loss of vital DC bus.

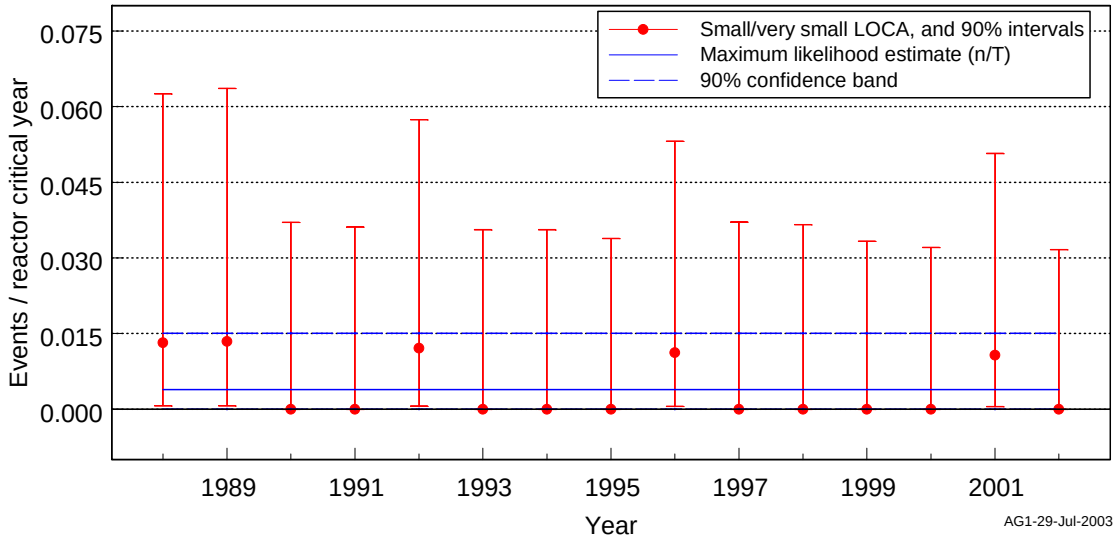

Figure 4. Frequency of initiating events with small/very small loss of coolant accident.

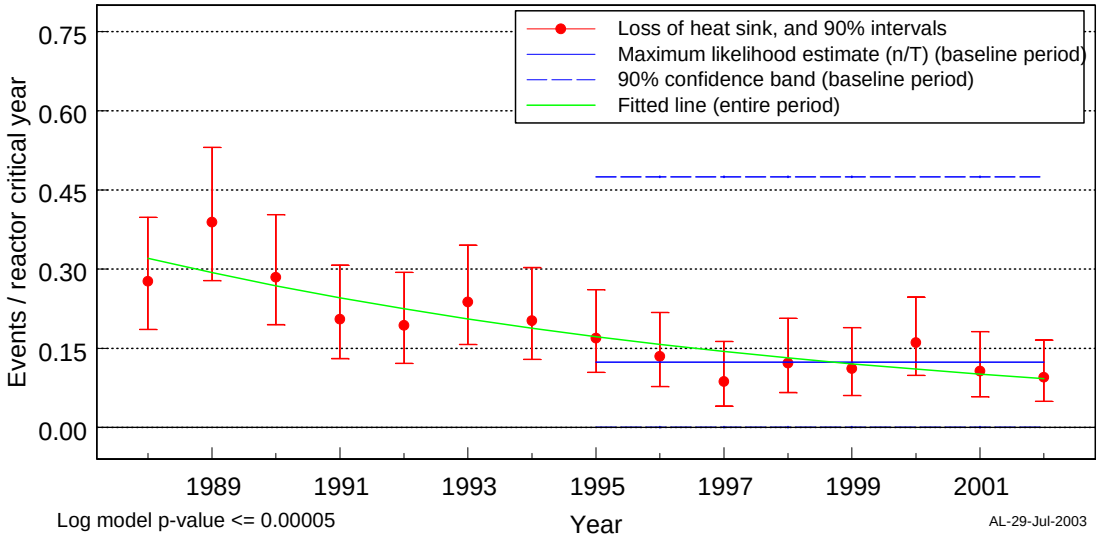

Figure 5. Frequency of initiating events with loss of heat sink.

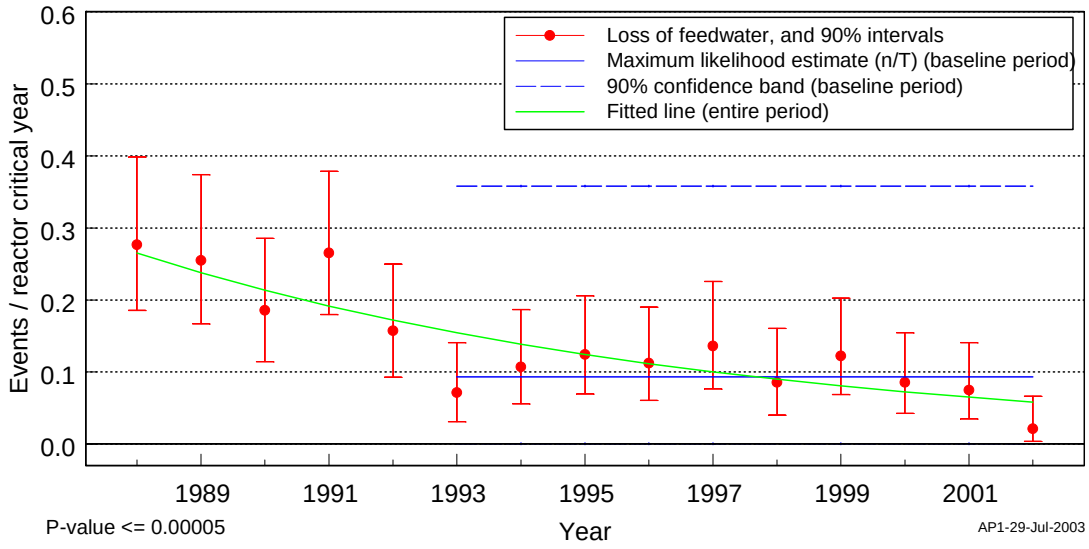

Figure 6. Frequency of initiating events with loss of feedwater.

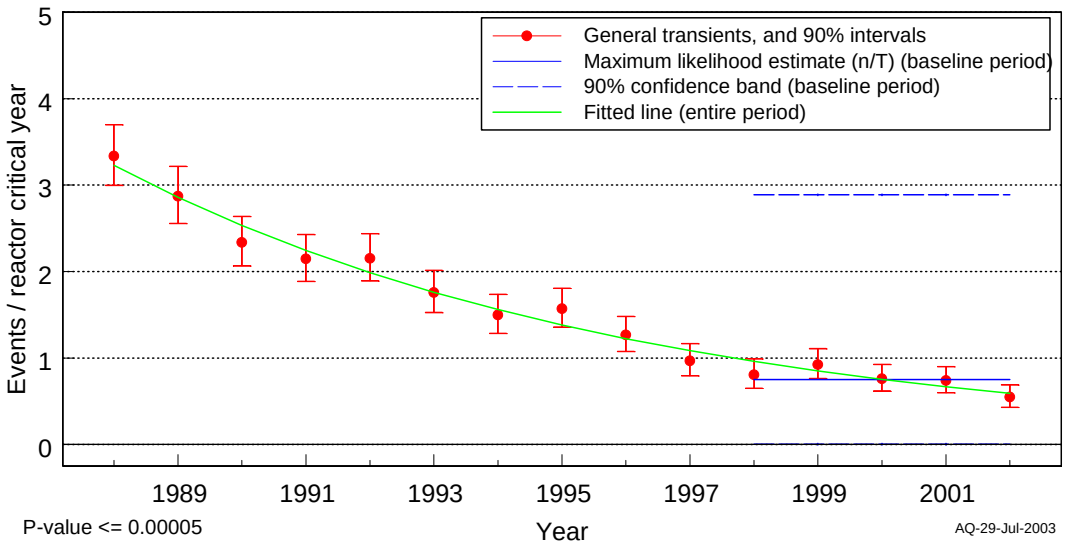

Figure 7. Frequency of initiating events with general transients.

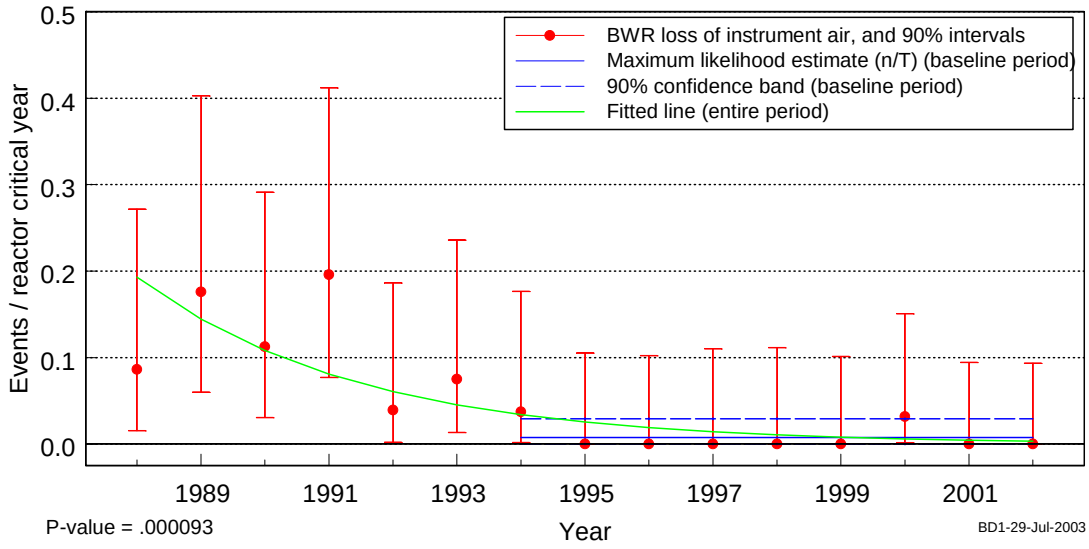

Figure 8. Frequency of BWR initiating events with loss of instrument air.

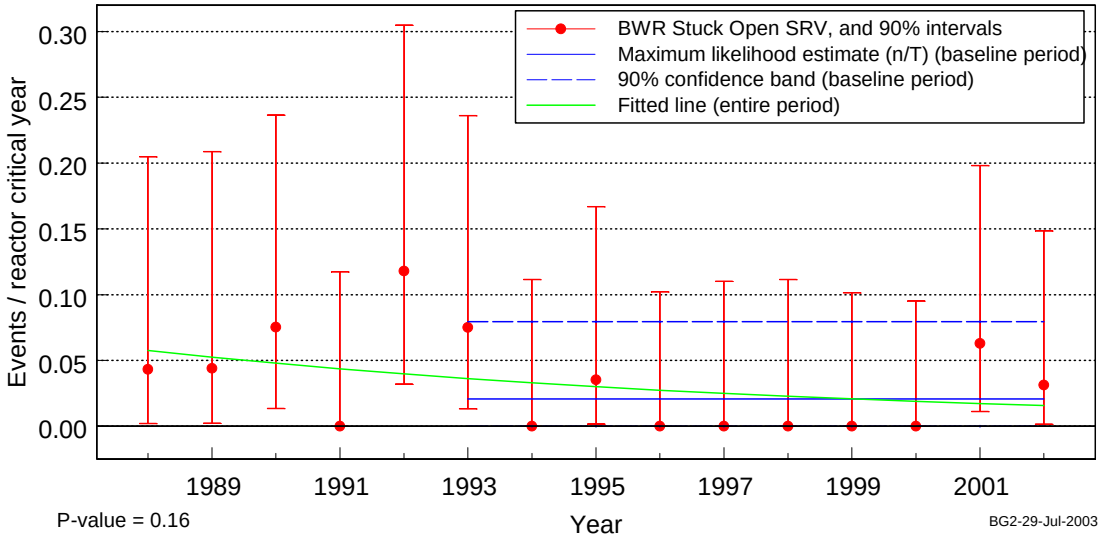

Figure 9. Frequency of BWR initiating events with stuck open safety relief valve.

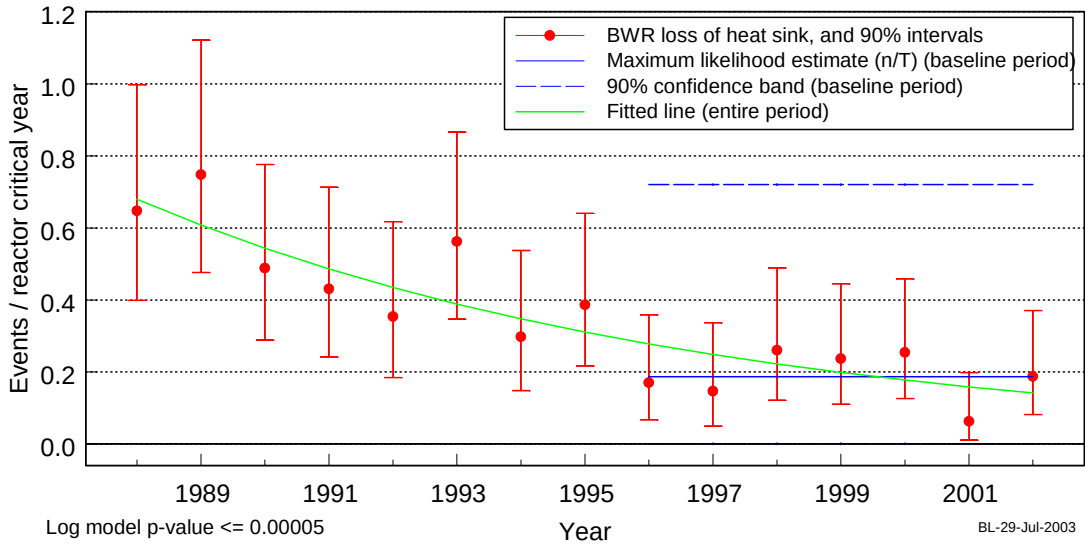

Figure 10. Frequency of BWR initiating events with loss of heat sink.

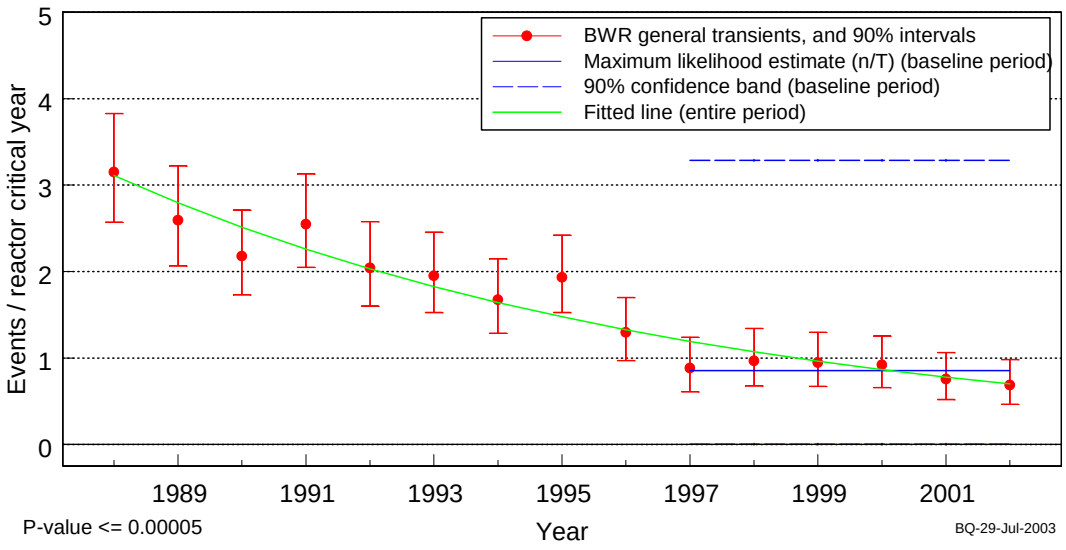

Figure 11. Frequency of BWR initiating events with general transients.

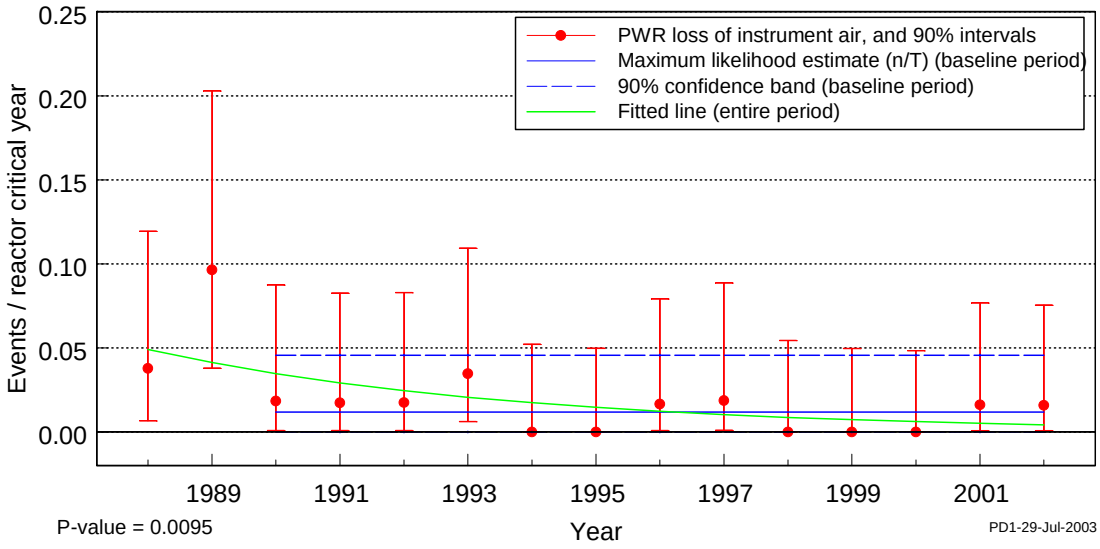

Figure 12. Frequency of PWR initiating events with loss of instrument air.

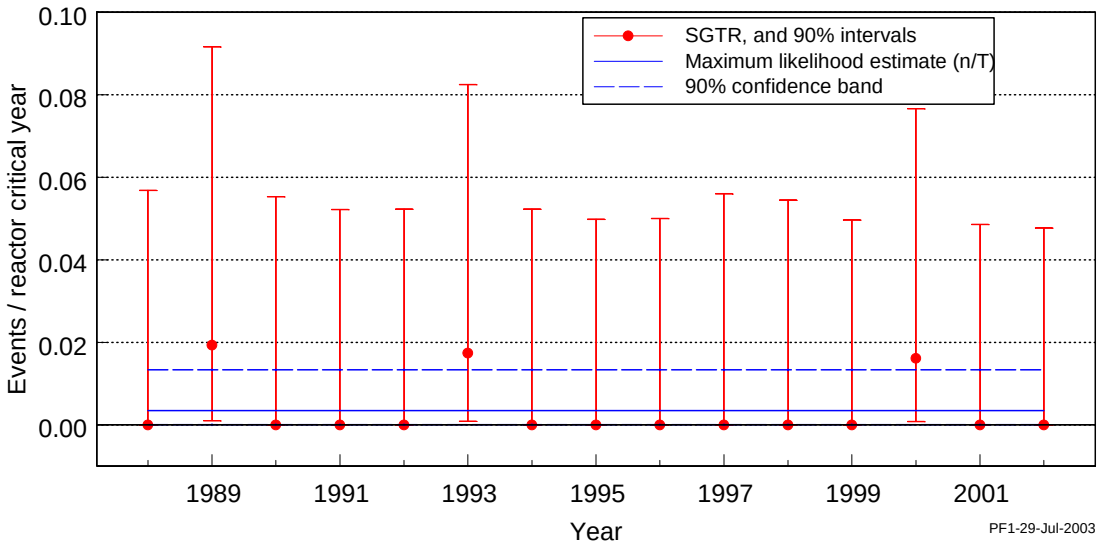

Figure 13. Frequency of PWR initiating events with steam generator tube rupture.

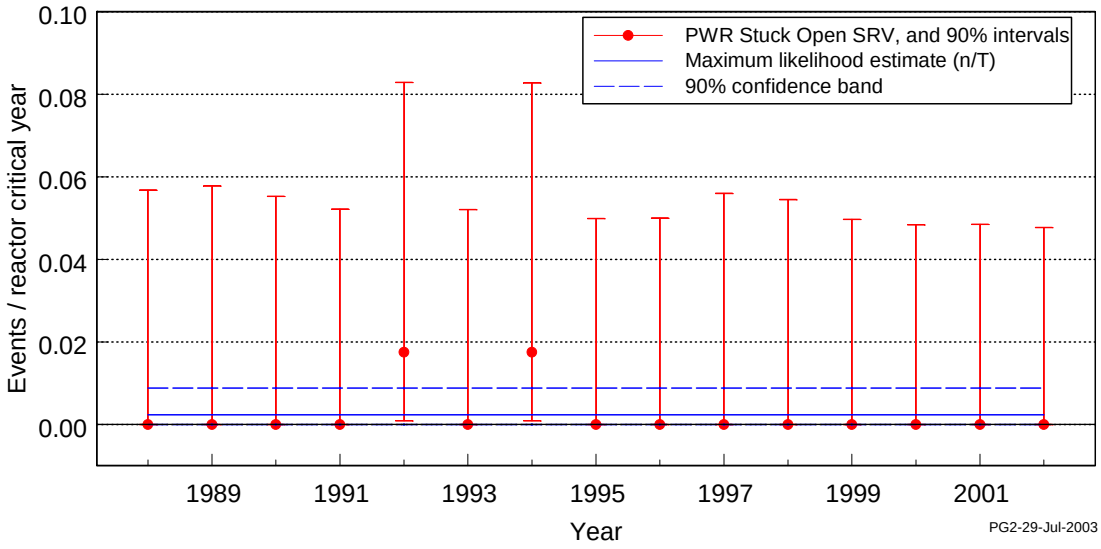

Figure 14. Frequency of PWR initiating events with stuck open safety relief valve.

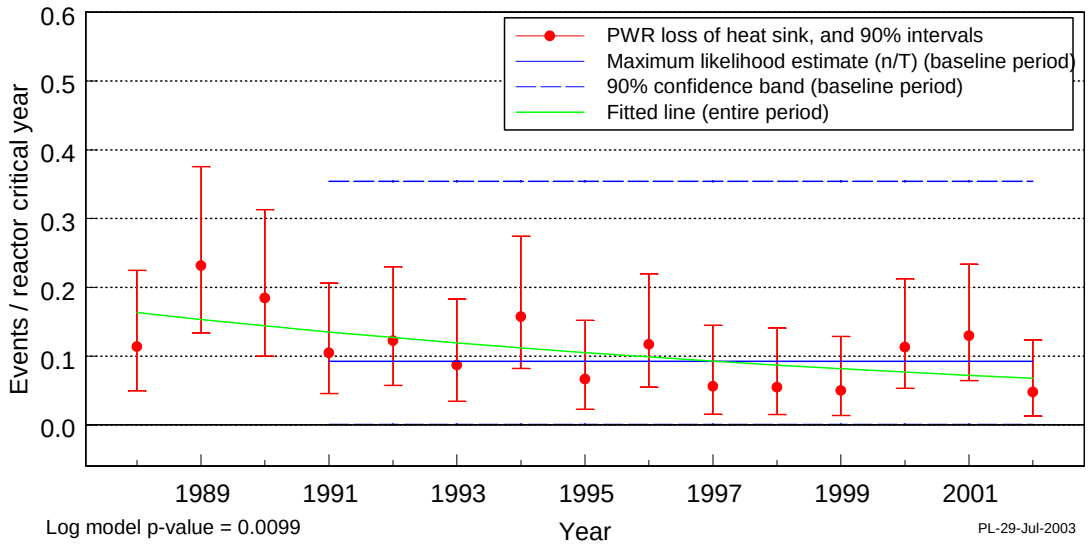

Figure 15. Frequency of PWR initiating events with loss of heat sink.

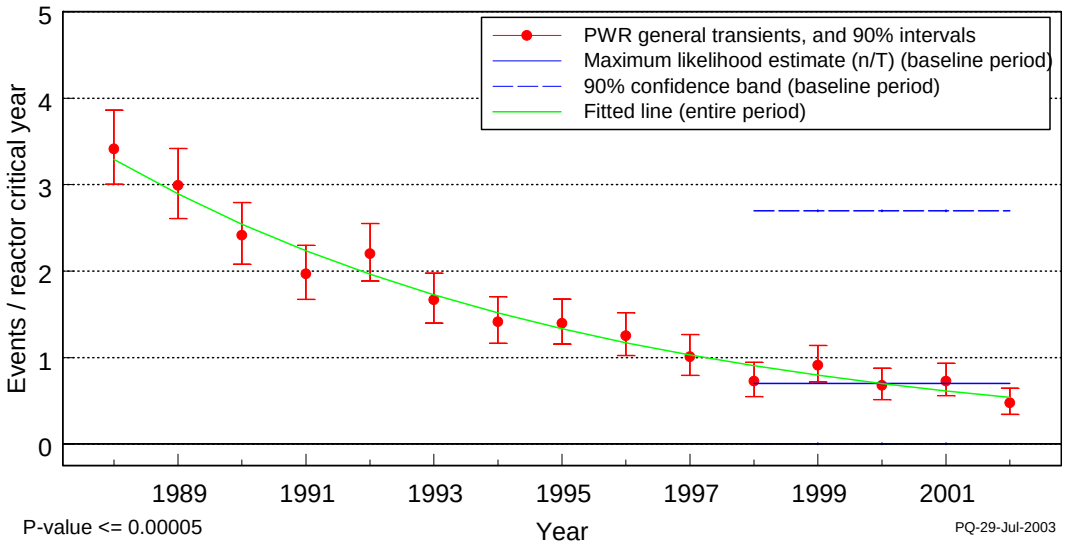

Figure 16. Frequency of PWR initiating events with general transients.