

Rates of Initiating Events at U.S. Nuclear Power Plants 1988–2004

This report presents an analysis of initiating event frequencies at United States (U.S.) commercial nuclear power plants. The evaluation is based on the operating experience from 1988 through 2004, as reported in Licensee Event Reports (LERs). This is the latest update to NUREG/CR 5750, updating data, frequency estimates, trends, and figures.

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 the possibility of a trend starting in 1988.

In accordance with the Industry Trend program, particular starting years have been identified for each of these initiating events for baseline periods during which the initiating event frequencies are approximately constant. The baseline periods for all of these initiating events have been extended to 2002. The maximum likelihood estimate (the total number of events divided by the total number of reactor critical years) has been taken as the mean for each occurrence rate in each year. For each baseline period, the mean is the ratio of the total event count (summed over the fiscal years in the baseline period), divided by the corresponding sum of reactor critical years.

The limits in each year are simple confidence bounds. For the baseline period, the horizontal limits are computed from the predictive distribution (Poisson-Gamma) that describes the number of events that would be expected in a following year based on the number of events (plus 0.5), the occurrence time in the baseline period, and the exposure time in the following year. The predictive bounds for the baseline period assume that the occurrences are following a constant rate for that period and the future. Comparing future data with those bounds helps to determine whether the data are changing.

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

Table 1 lists the initiating events, overall data, and horizontal bounds used in the plots.

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).

Table 1. Initiating events with baseline frequencies.

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	58	1464.08	1997	0.00E+00	1.31E-02*	5.38E-02
Loss of vital AC bus	Figure 2	43	1464.08	1988	0.00E+00	2.98E-02	7.53E-02
Loss of vital DC bus	Figure 3	3	1464.08	1988	0.00E+00	2.35E-03	2.15E-02
Small/very small LOCA	Figure 4	5	1464.08	1988	0.00E+00	3.92E-03	3.23E-02
Loss of heat sink	Figure 5	259	1464.08	1995	6.45E-02	1.24E-01	2.04E-01
Loss of feedwater	Figure 6	188	1464.08	1993	4.30E-02	9.32E-02	1.61E-01
General transients	Figure 7	2120	1464.08	1998	6.02E-01	7.57E-01	9.36E-01
BWR loss of instrument air	Figure 8	19	476.76	1994	0.00E+00	7.60E-03	6.39E-02
BWR stuck open SRV	Figure 9	14	476.76	1993	0.00E+00	2.07E-02	9.58E-02
BWR loss of heat sink	Figure 10	154	476.76	1996	6.39E-02	1.88E-01	3.83E-01
BWR general transients	Figure 11	699	476.76	1997	5.75E-01	8.56E-01	1.18E+00
PWR loss of instrument air	Figure 12	17	987.32	1990	0.00E+00	1.19E-02	6.48E-02
PWR steam generator tube rupture	Figure 13	3	987.32	1988	0.00E+00	3.48E-03	3.24E-02
PWR stuck open SRV	Figure 14	2	987.32	1988	0.00E+00	2.30E-03	3.24E-02
PWR loss of heat sink	Figure 15	105	987.32	1991	3.24E-02	9.23E-02	1.78E-01
PWR general transients	Figure 16	1421	987.32	1998	5.19E-01	7.10E-01	9.24E-01

* For the loss of offsite power, the 2003 major grid related events, as well as the 2004 events, are not reflected in the baseline mean. See the Reevaluation of Station Blackout Risk at Nuclear Power Plants, NUREG/CR-XXXX, Volume 1, for a mean (3.59E-02) which reflects all events through 2004. (The NUREG/CR is expected to be released by December 2005.)

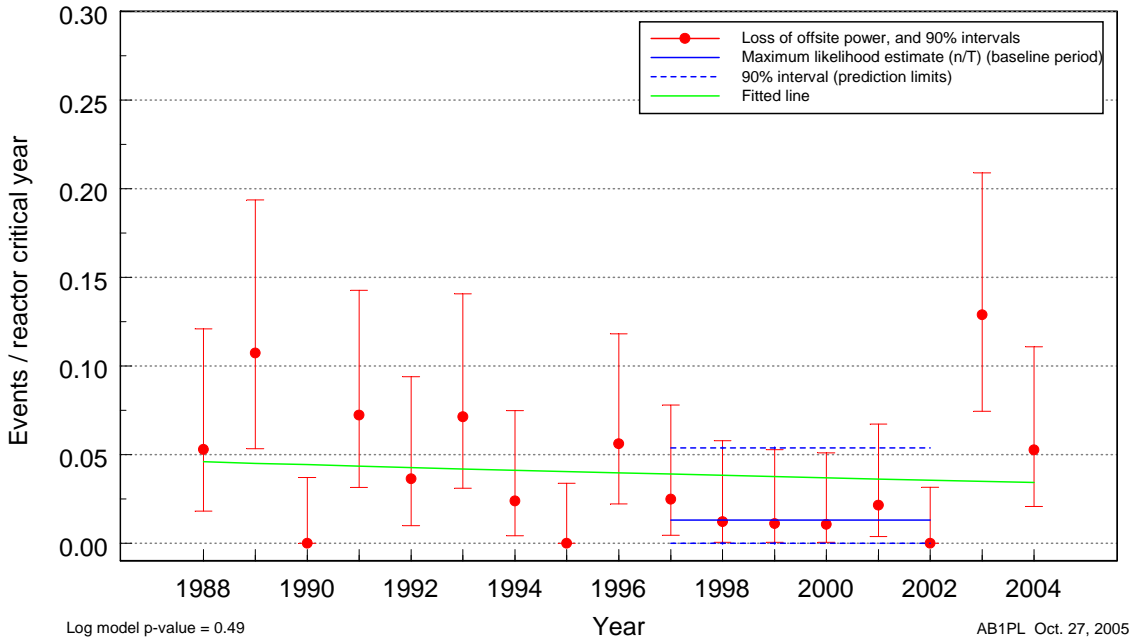


Figure 1. Frequency of initiating events with a loss of off-site power.

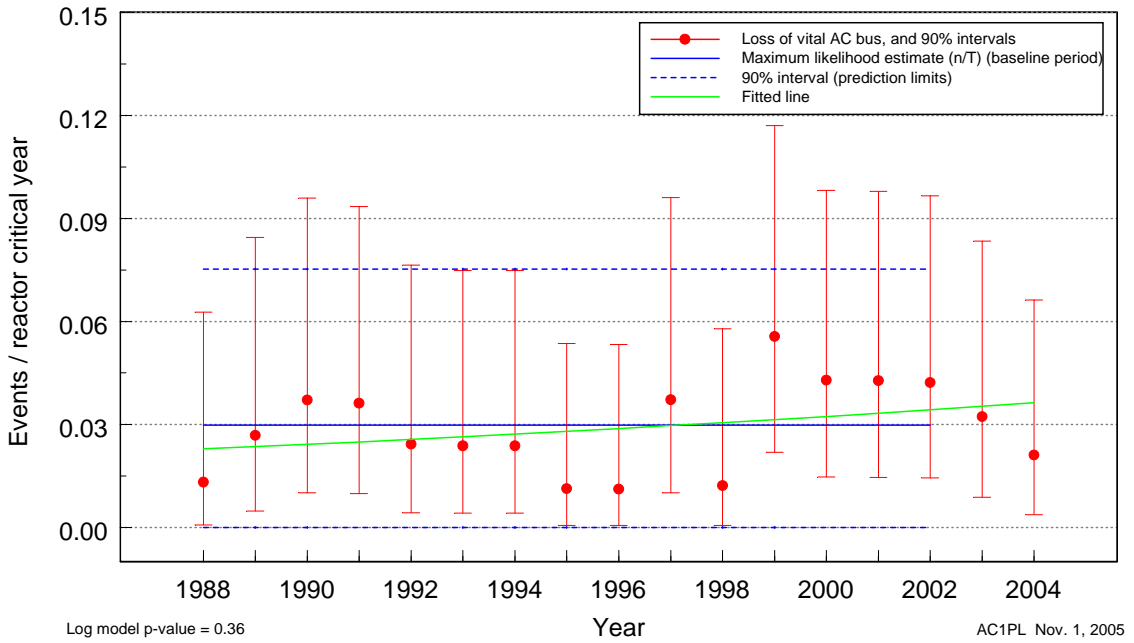


Figure 2. Frequency of initiating events with loss of vital AC bus.

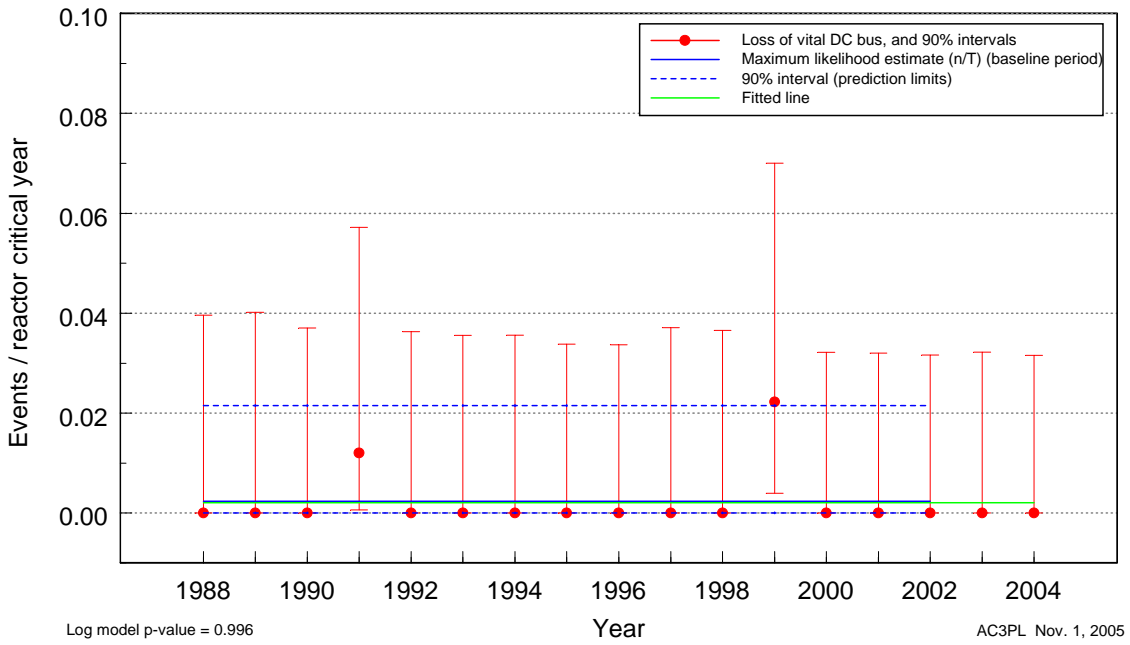


Figure 3. Frequency of initiating events with loss of vital DC bus.

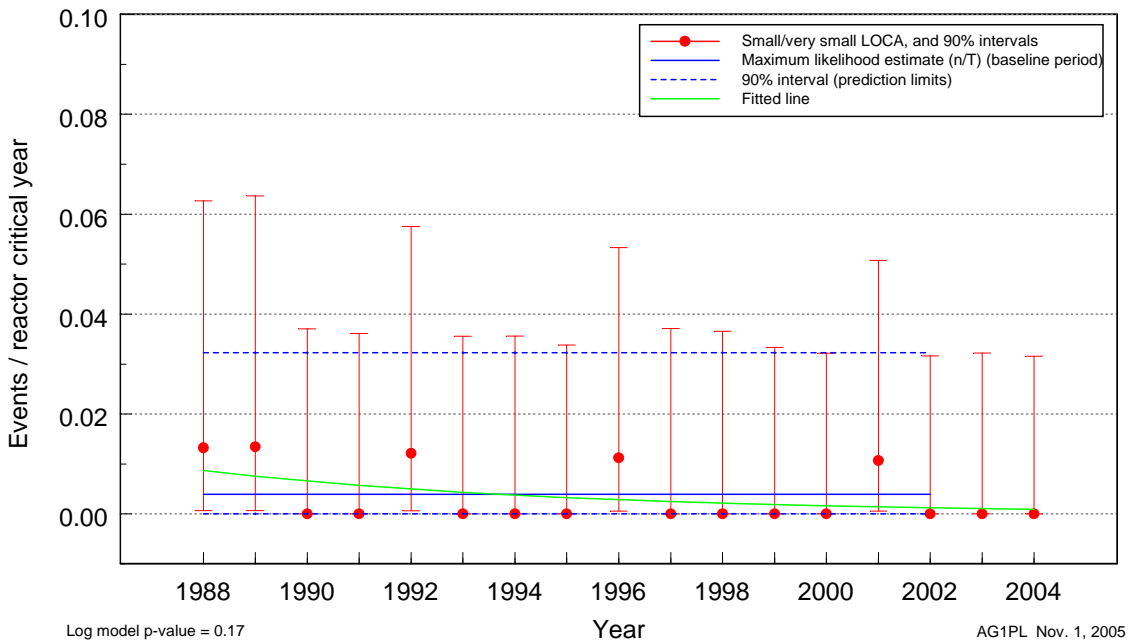


Figure 4. Frequency of initiating events with small/very small loss of coolant accident.

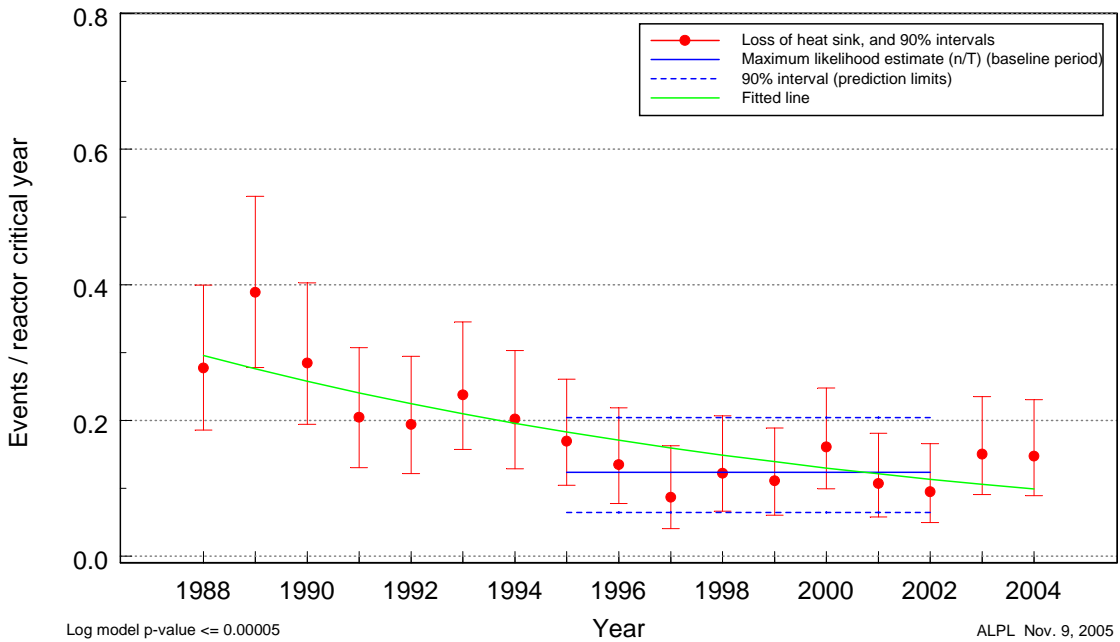


Figure 5. Frequency of initiating events with loss of heat sink.

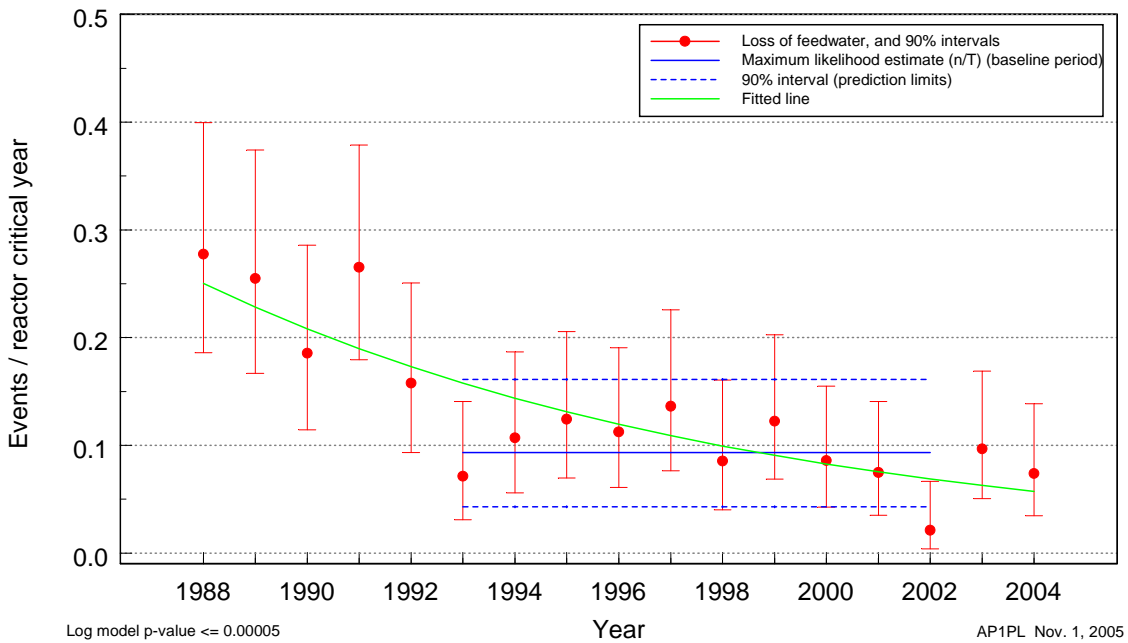


Figure 6. Frequency of initiating events with loss of feedwater.

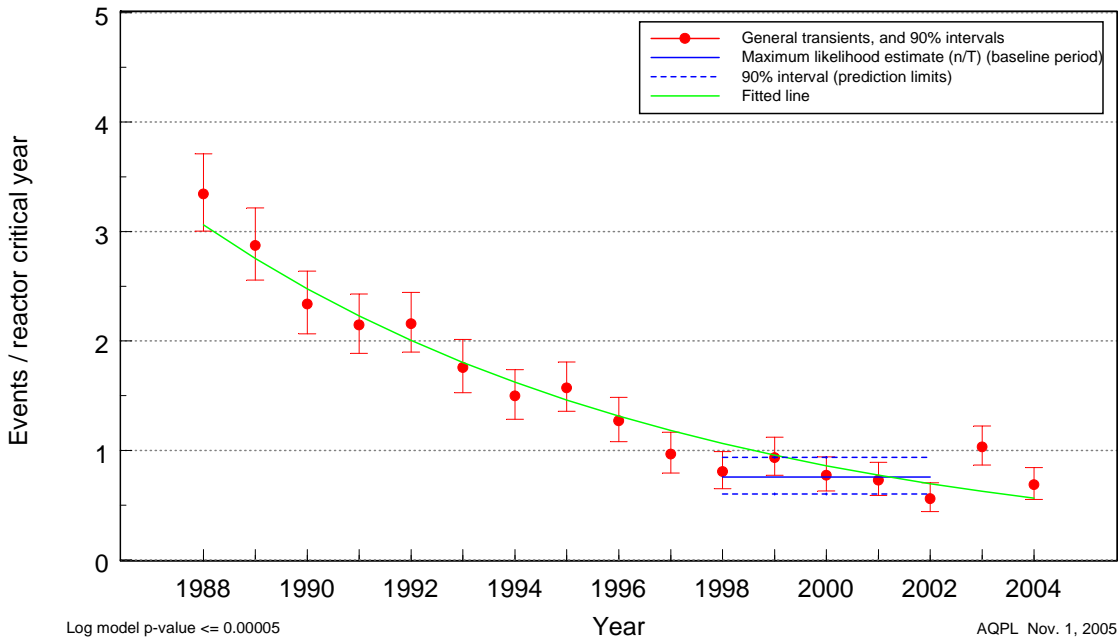


Figure 7. Frequency of initiating events with general transients.

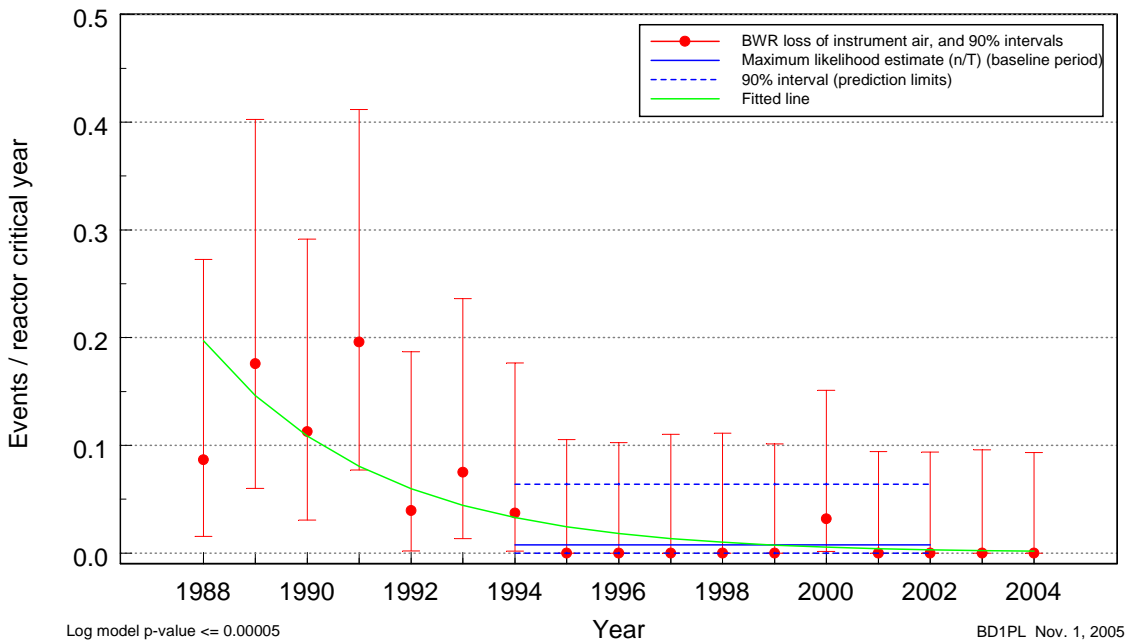


Figure 8. Frequency of BWR initiating events with loss of instrument air.

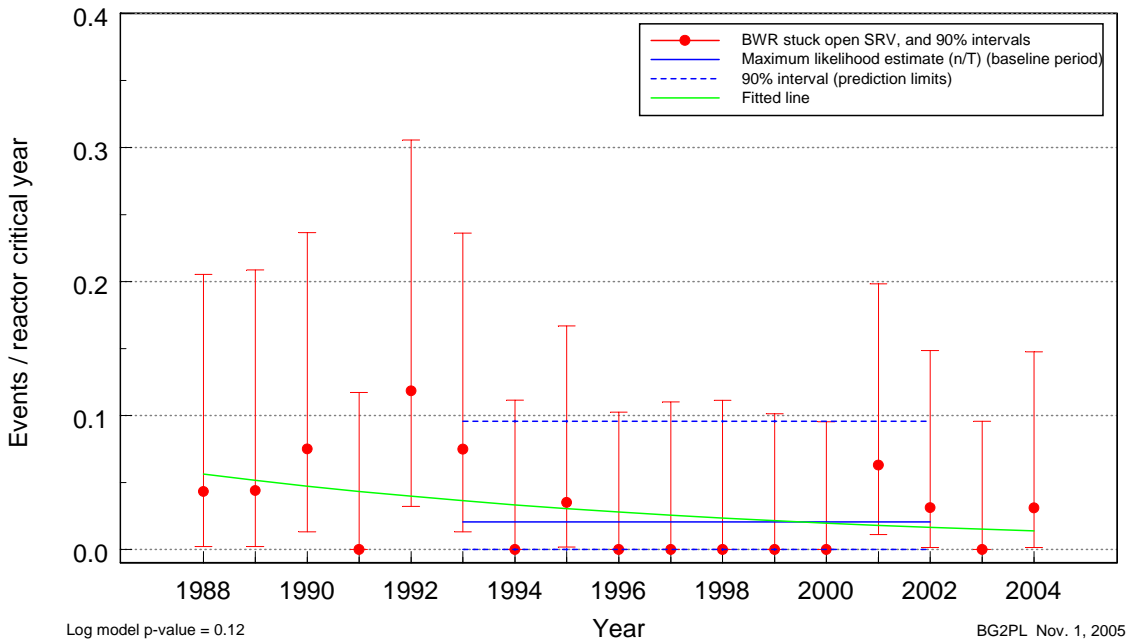


Figure 9. Frequency of BWR initiating events with stuck open safety relief valve.

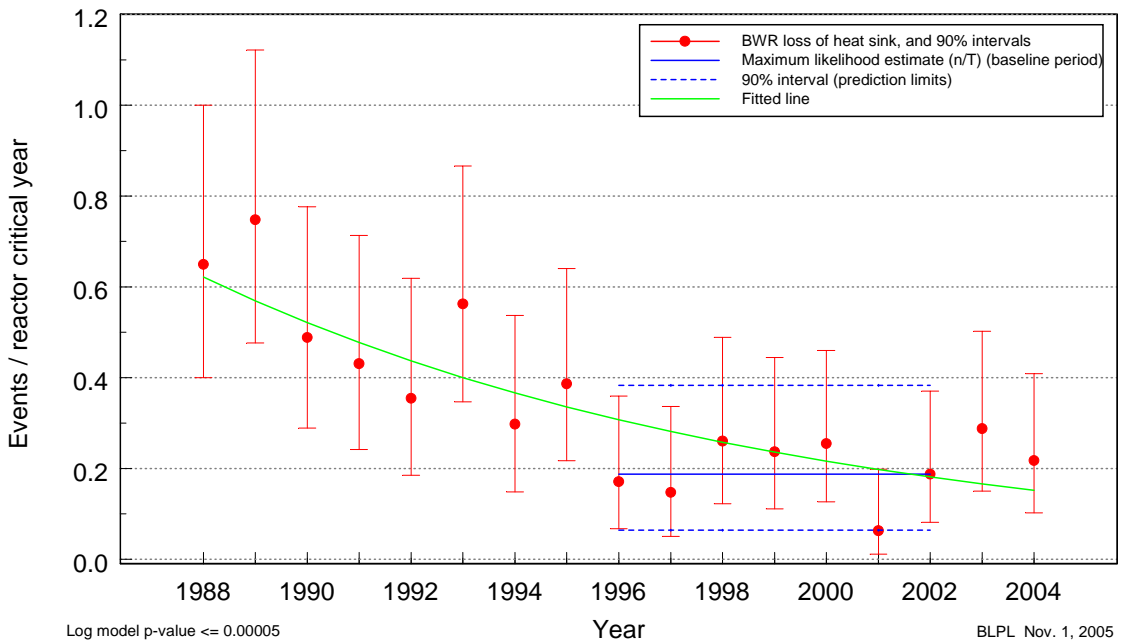


Figure 10. Frequency of BWR initiating events with loss of heat sink.

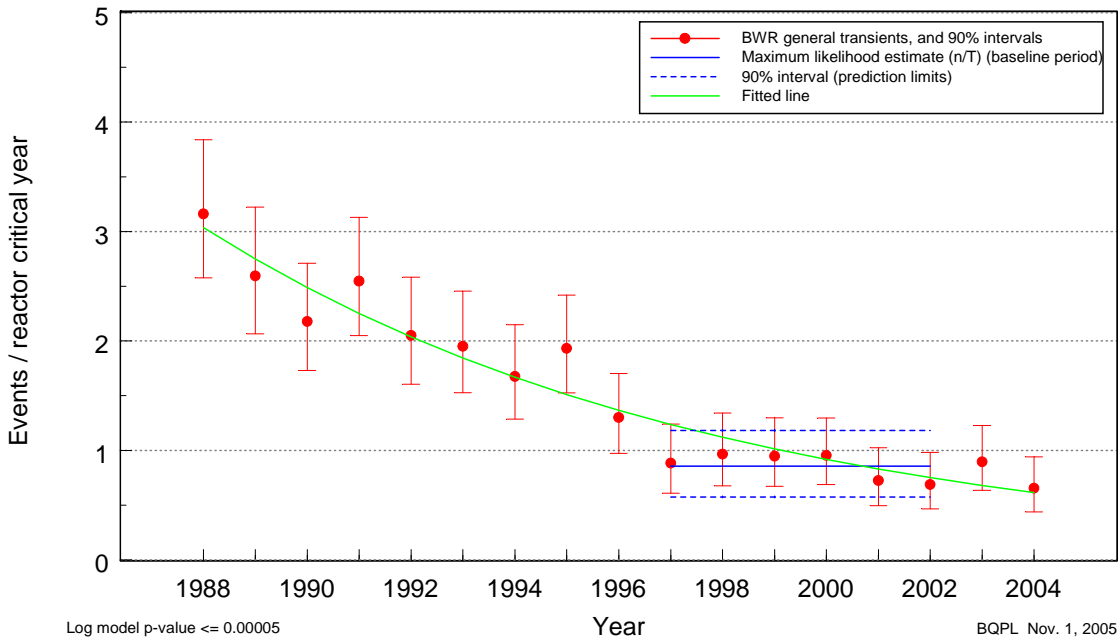


Figure 11. Frequency of BWR initiating events with general transients.

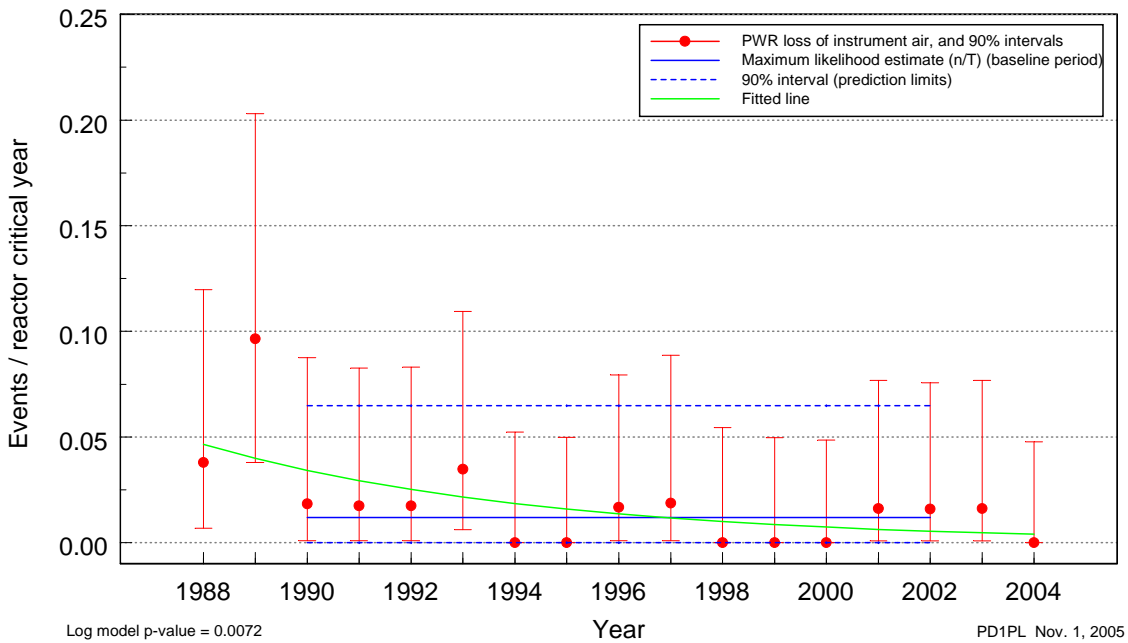


Figure 12. Frequency of PWR initiating events with loss of instrument air.

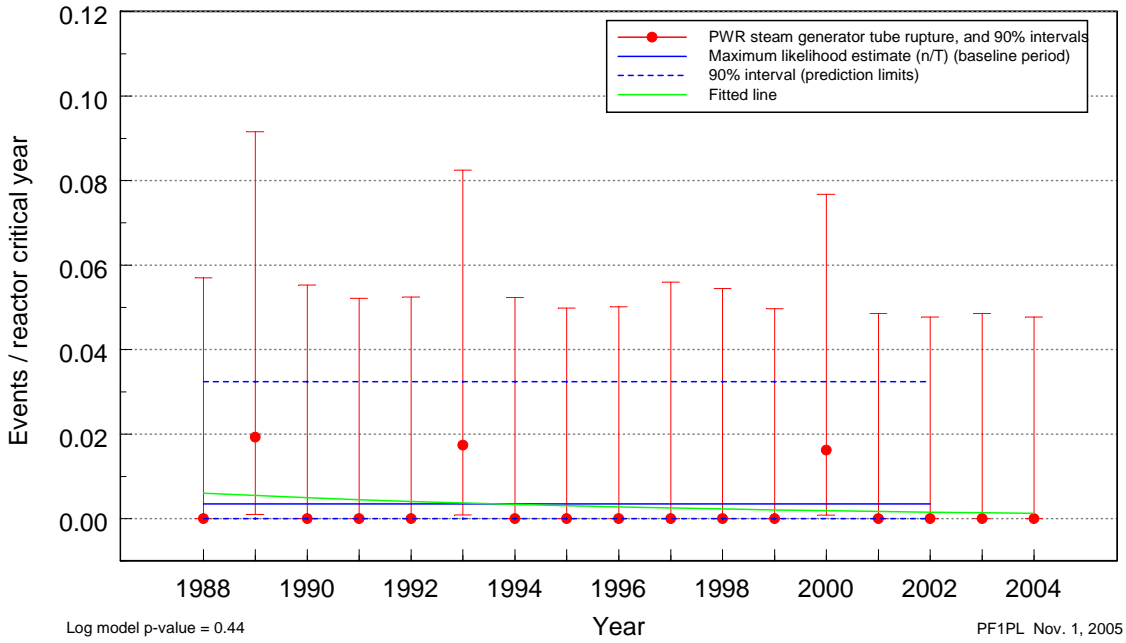


Figure 13. Frequency of PWR initiating events with steam generator tube rupture.

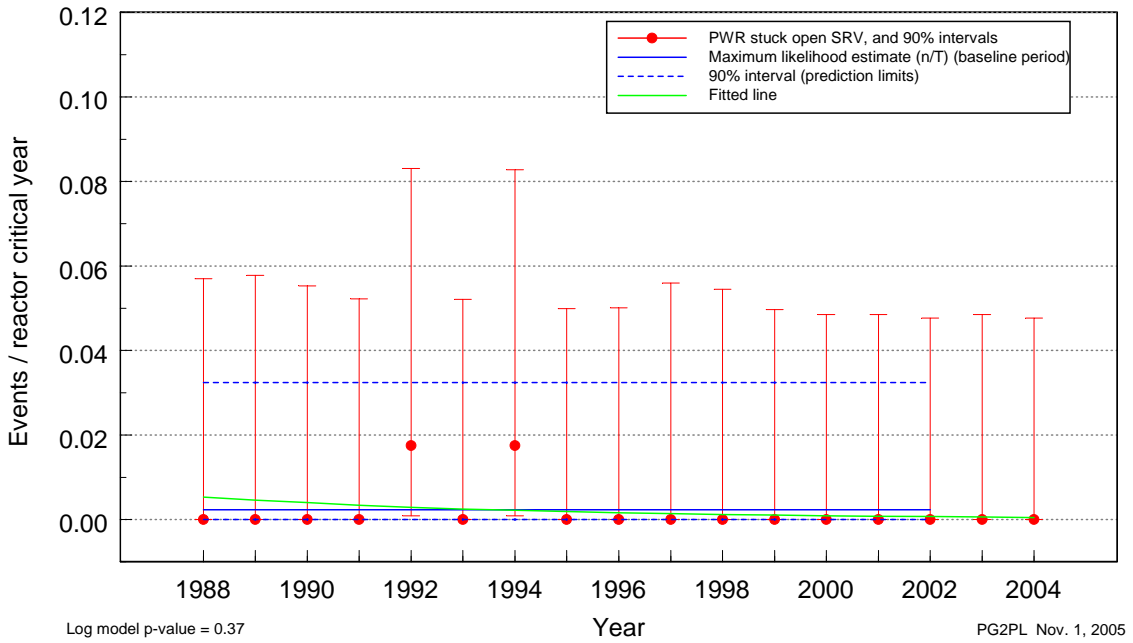


Figure 14. Frequency of PWR initiating events with stuck open safety relief valve.

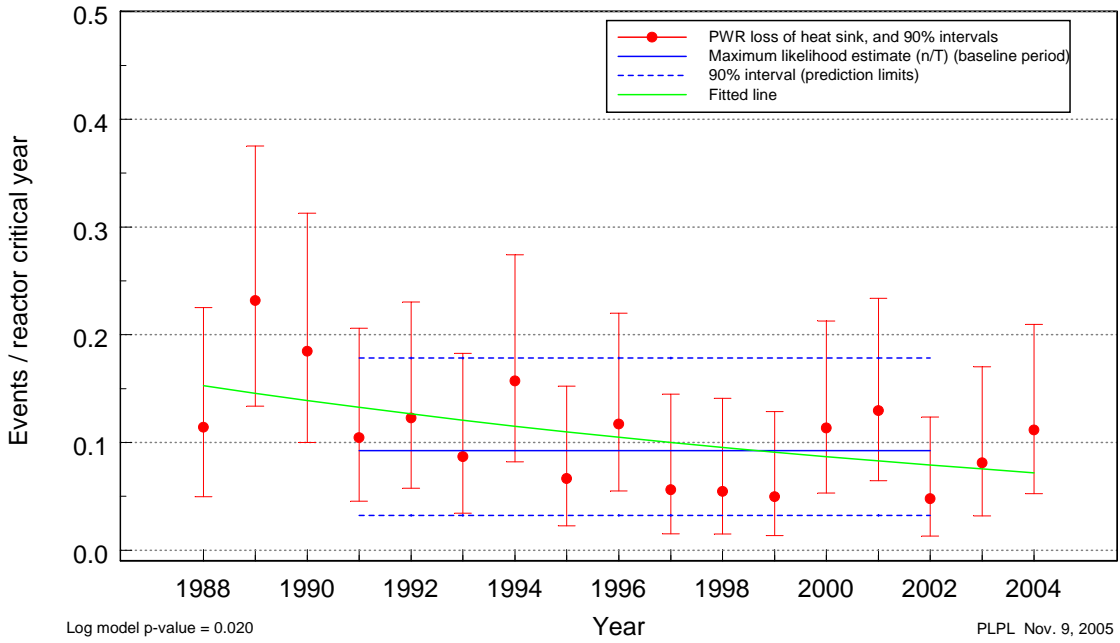


Figure 15. Frequency of PWR initiating events with loss of heat sink.

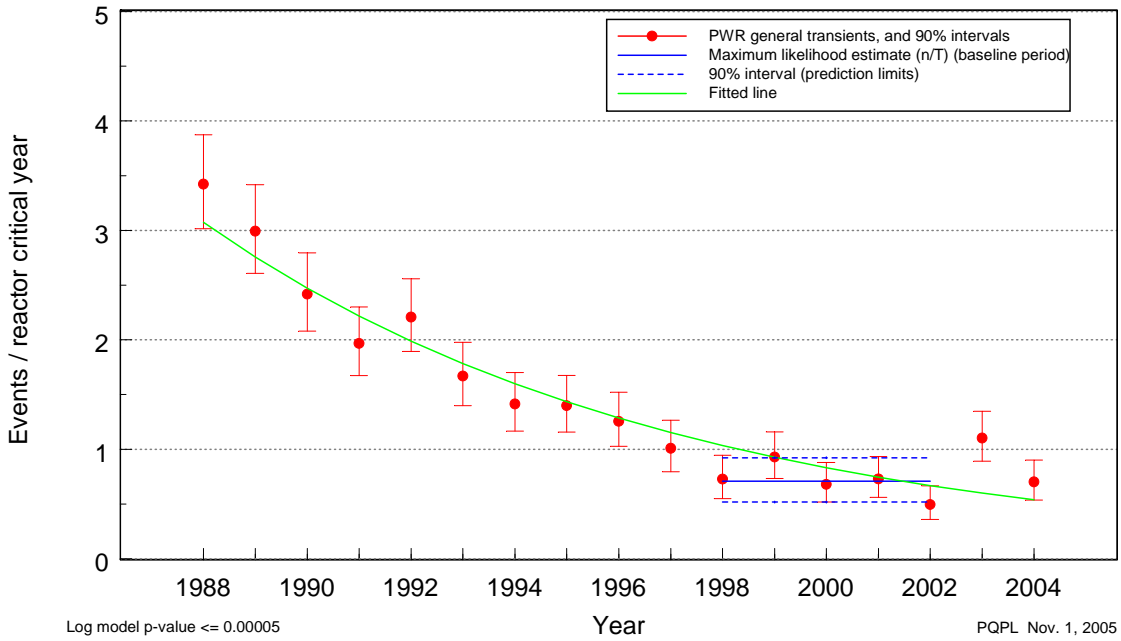


Figure 16. Frequency of PWR initiating events with general transients.