Results and Databases Trend Summary

1998–2010

1 INTRODUCTION

This report presents a summary of reliability and frequency trends reported in several separate reports available on the NRC Operating Experience web site. Each report lists the significant[1], either increasing or decreasing, trends identified in each report and this report puts those trends in a single location. The figure numbers of significant trends are the figure number in the referenced report. This report does not estimate values for use in probabilistic risk assessments (PRAs), but does evaluate performance over time.

The trend evaluations in this study are based on the operating experience reports from fiscal year (FY) 1998 through FY 2010 as they are collected in the Integrated Data Collection and Calculation System (IDCCS). An overview of the trending methods, glossary of terms, and abbreviations can be found in the Overview and Reference document on the Reactor Operational Experience Results and Databases web page.

2 COMPONENT PERFORMANCE

2.1 Air-Operated Valves

The results of air-operated valves (AOVs) are summarized in this section. Of particular interest is the existence of any statistically significant increasing trends. In this update, no statistically significant increasing trends were identified in the AOV results.

Statistically significant decreasing trends were identified in the AOV results for the following:

- All systems, industry-wide AOV FTOC trend AOVs with ≤ 20 demands per year. (see Figure 1)
- All systems, industry-wide AOV FTOC trend AOVs with > 20 demands per year. (see Figure 2)
- Frequency (failures per reactor year) of AOV FTOC events > 20 demands per year. (see Figure 10)

Highly statistically significant decreasing trends were identified in the AOV results for the following:

- Frequency (failures per reactor year) of AOV FTOC events ≤ 20 demands per year. (see Figure 9)

[1] Statistical significance 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).

Extremely statistically significant decreasing trends were identified in the AOV results for the following:

- Frequency (demands per reactor year) of AOV operation demands, ≤ 20 demands per year. (see Figure 7)

2.2 Emergency Diesel Generators

The results of emergency diesel generators (EDGs) are summarized in this section. Of particular interest is the existence of any statistically significant increasing trends. In this update, the following highly statistically significant increasing trends were identified in the EDG results:

- EPS, industry-wide EDG FTR>1H trend. (see Figure 3)
- EPS, industry-wide EDG unreliability trend (8-hour mission). (see Figure 9)
- Frequency (events per reactor year) of FTR>1H events, EPS and HPCS EDGs (see Figure 16)

The increasing trend in the EPS EDG unreliability (Figure 9) is primarily due to the increasing trend in the greater than 1 hour failure to run events (reflected in Figure 3 and Figure 16). In 2008, the staff at the Idaho National Laboratory (INL) reviewed the EPIX data for EDGs and found that many EDG failures that were originally counted as failure to start are more correctly classified as failure to run. The results of this review are reflected in this update.

Statistically significant decreasing trends were identified in the EDG results for the following:

- The 2002 to 2010 EDG UA in the EPS EDG UA trend (see Figure 7).

Highly statistically significant decreasing trends were identified in the EDG results for the following:

- Frequency (events per reactor year) of start demands, EPS and HPCS EDGs (see Figure 11)
- Frequency (events per reactor year) of load and run ≤ 1 hour demands, EPS and HPCS EDGs (see Figure 12)

It is uncertain what leads to the decrease in EDG start and load and run demands over time since 1998. The plots show that a step change in the rates of EDG start and load and run demands starts in 2003, which is coincident with the heightened reporting required by the MSPI program.

2.3 Motor-Driven Pumps

The results of motor-driven pumps (MDPs) are summarized in this section. Of particular interest is the existence of any statistically significant increasing trends. In this update, the following statistically significant increasing trends were identified in the MDP results.

- Standby MDP run hours per reactor critical year. (see Figure 11)
- Frequency (demands per reactor year) of start demands, normally running MDPs. (see Figure 15)
- Normally running MDP run hours per reactor critical year. (see Figure 16)

These trends are not adverse trends; they only indicate an increase in run hours for standby pumps and demands for normally running pumps. Standby MDP run hours appear to have made a step change in the upward direction in FY 2003, which coincides with the start of the MSPI program. This gives an increasing trend over the 1998 to 2010 period. Normally running MDP start demands have increased

from approximately 81 to 93 start demands per reactor year. The trend is significant, but the increase is not. Statistically significant decreasing trends were identified in the MDP results for the following:

- Standby systems, industry-wide MDP FTS trend. (see Figure 1)
- Normally running systems, industry-wide MDP FTS trend. (see Figure 4)
- Pooled AFW, HPI, and HCS MDP UA trend. (see Figure 6)
- Standby systems, industry-wide MDP unreliability trend (8-hour mission). (see Figure 7)
- Normally running systems (MFW), industry-wide MDP unreliability trend (8-hour mission). (see Figure 8)
- Frequency (failures per reactor year) of FTS events, standby MDPs. (see Figure 12)
- Frequency (failures per reactor year) of FTS events, normally running MDPs. (see Figure 17)

2.4 Motor-Operated Valves

The results of motor-operated valves (MOVs) are summarized in this section. Of particular interest is the existence of any statistically significant increasing trends. In this update, no statistically significant increasing trends were identified in the MOV results. Statistically significant decreasing trends were identified in the MOV results for the following:

- All systems, industry-wide MOV FTOC trend MOVs with ≤ 20 demands per year. (see Figure 1)
- All systems, industry-wide MOV FTOC trend MOVs with > 20 demands per year. (see Figure 2)
- Frequency (demands per reactor year) of MOV operation demands, ≤ 20 demands per year. (see Figure 7)
- Frequency (failures per reactor year) of MOV FTOC events ≤ 20 demands per year. (see Figure 9)
- Frequency (failures per reactor year) of MOV FTOC events > 20 demands per year. (see Figure 10)

2.5 Turbine-Driven Pumps

The results of turbine-driven pumps (TDPs) are summarized in this section. Of particular interest is the existence of any statistically significant increasing trends. In this update, no highly statistically significant increasing trends were identified in the TDP results.

Statistically significant decreasing trends were identified in the TDP results for the following:

- Pooled AFW, HPCI, and RCIC TDP UA trend. (see Figure 6)
- Standby TDP run hours per reactor critical year. (see Figure 11)
- Frequency (events per reactor year) of start demands, normally running TDPs. (see Figure 15)

3 LOSS OF OFFSITE POWER EVENTS

None of the loss of offsite power (LOOP, also referred to as LOSP) trend plots show statistically significant increasing or decreasing trends.

4 RATES OF INITIATING EVENTS

The results of occurrence rates for the categories of initiating events summarized in this section. Sixteen initiating event groupings are trended and displayed. Note that the LOOP trend presented here is the trend of all LOOP categories.

Table 1. Summary of initiating event trend figures.

Figure	Description	p-value	Trend Direction	Trend Significance
1	LOOP - Loss of Offsite Power	0.0025	decreasing	High
2	LOAC - Loss of AC Power	0.9200	--	
3	LODC - Loss of DC Power	0.9500	--	
4	SLOCA - Small Loss of Coolant Accident	0.0860	--	
5	PLOCCW - Partial Loss of Component Cooling Water	0.1700	--	
6	LOMFW - Loss of Main Feedwater	0.0001	decreasing	Extreme
7	PLOSWS - Partial Loss of Service Water System	0.7200	--	
8	LOIA (BWR) - Loss of Instrument Air (BWR)	0.0006	decreasing	Extreme
9	SORV (BWR) - Stuck Open Relief Valve (BWR)	0.0250	decreasing	Significant
10	LOCHS (BWR) - Loss of Condensed Heat Sink (BWR)	0.0001	decreasing	Extreme
11	TRANS (BWR) - Transients (BWR)	0.0001	decreasing	Extreme
12	LOIA (PWR) - Loss of Instrument Air (PWR)	0.0570	--	
13	SGTR (PWR) - Steam Generator Tube Rupture (PWR)	0.1900	--	
14	SORV (PWR) - Stuck Open Relief Valve (PWR)	0.2200	--	
15	LOCHS (PWR) - Loss of Condenser Heat Sink (PWR)	0.0001	decreasing	Extreme
16	TRANS (PWR) - Transients (PWR)	0.0001	decreasing	Extreme

5 SYSTEM STUDIES

5.1 Auxiliary Feedwater System

The results of the auxiliary feedwater system (AFW) unreliability study are summarized in this section. Of particular interest is the existence of any statistically significant increasing trends. In this update, no statistically significant increasing trends were identified in the AFW unreliability trend results. In addition, this update identified no statistically significant decreasing trends in the AFW results.

6 EMERGENCY POWER SYSTEM

The results of the emergency power system (EPS) system unreliability study are summarized in this section. Of particular interest is the existence of any statistically significant increasing trends. In this update, two statistically significant increasing trends were identified in the EPS unreliability trend results.

- Trend of EPS system unreliability (start-only model), as a function of fiscal year. (see Figure 3)
- Trend of EPS system unreliability (8-hour model), as a function of fiscal year. (see Figure 4)

The absolute change in the EPS reliability is small; however, the statistical significance of the trend is below the threshold of statistical significance. The increasing trend reflects the increasing trend in the Emergency Diesel Generator (EDG) unreliability as noted in the component performance study for EDGs.

This update identified no statistically significant decreasing trends in the EPS results.

6.1 High Pressure Coolant Injection

The results of the high pressure coolant injection (HPCI) system unreliability study are summarized in this section. Of particular interest is the existence of any statistically significant increasing trends. In this update, no statistically significant increasing trends were identified in the HPCI unreliability trend results. No statistically significant decreasing trends within the industry-wide estimates of HPCI system unreliability on a per fiscal year basis were identified.

6.2 High Pressure Core Spray

The results of the high pressure core spray (HPCS) system unreliability study are summarized in this section. Of particular interest is the existence of any statistically significant increasing trends. In this update, no statistically significant increasing trends were identified in the HPCS unreliability trend results. In addition, this update identified no statistically significant decreasing trends in the HPCS results.

6.3 High Pressure Safety Injection

The results of the high-pressure safety injection system (HPSI) unreliability study are summarized in this section. Of particular interest is the existence of any statistically significant increasing trends. In this update, no statistically significant increasing trends were identified in the HPSI unreliability trend results. In addition, this update identified no statistically significant decreasing trends in the HPSI results.

6.4 Isolation Condenser

The results of the isolation condenser (ISO) system unreliability study are summarized in this section. Of particular interest is the existence of any statistically significant increasing trends. In this update, no statistically significant increasing trends were identified in the ISO unreliability trend results. In addition, this update identified no statistically significant decreasing trends in the ISO results.

6.5 Reactor Core Isolation Cooling

The results of reactor core isolation cooling (RCIC) system unreliability study are summarized in this section. Of particular interest is the existence of any statistically significant increasing trends. In this update, no statistically significant increasing trends were identified in the RCIC unreliability trend results. In addition, this update identified no statistically significant decreasing trends in the RCIC results.

6.6 Residual Heat Removal System

The results of the residual heat removal (RHR) system unreliability study are summarized in this section. Of particular interest is the existence of any statistically significant increasing trends. In this update, no statistically significant increasing trends were identified in the RHR unreliability trend results.

Highly statistically significant decreasing trends in the RHR LPI results were identified for:

- Trend of RHR (injection mode) system unreliability (start-only model), as a function of fiscal year. (see Figure 5)

- Trend of RHR (injection mode) system unreliability (8-hour model), as a function of fiscal year. (see Figure 6)

No statistically significant decreasing trends in the RHR SDC results were identified.