Reliability Study Update

Reactor Core Isolation Cooling

1987–2004

This report presents a performance evaluation of the reactor core isolation cooling (RCIC) system at 30 U.S. commercial boiling water reactors (BWRs). The evaluation is based on the operating experience from 1987 through 2004, as reported in Licensee Event Reports (LERs). This is the latest update to NUREG/CR-5500 Volume 7, updating data, availability and reliability estimates, trends, and figures.

This report calculates two basic models for the RCIC system. The FTS model includes the start and recovery of the pump and the initial opening of the injection valve. The 8-hour mission model includes the RCIC system start and operation for 8 hours. Restart of the RCIC turbine, multiple injections, transfer from recirculation to injection, and recovery actions are included. Both models include failures due to the unavailability while in maintenance. See the RCIC Fault Tree Description document for more detail.

1 LATEST VALUES AND TRENDS

1.1 Industry-Wide Unavailability and Unreliability

The industry-wide unavailability and unreliability of the RCIC system have been estimated from operating experience. A failure to start (FTS) model and an 8-hour mission model were evaluated for each of these models, see Table 1. The estimates are based on failures that occurred during unplanned demands, and cyclic and quarterly surveillance tests.

Table 1. Industry-wide values.

Model	Lower (5%)	Mean	Upper (95%)
Failure-to-Start (Unavailability)	4.85E-03	1.37E-02	2.62E-02
8-hour Mission (Unreliability)	2.05E-02	5.18E-02	9.39E-02

1.2 Fail to Start Model Results

Individual plant result unavailability has been calculated for the FTS model. The current data set identified differences between earlier (1986 to 1995) and later (1996 to 2004) data for the fail-to-start injection (decreased) and the probability of multiple injection (increased) failure modes. The later data set does not show plant to plant differences in the data. Therefore, the waterfall chart for plant differences is not shown.

No statistically significant[1] trend within the industry estimates of RCIC system unavailability (FTS) on a per fiscal year basis was identified. Figure 1 shows the trend in the FTS model unavailability. Table 5 shows the data points for Figure 1.

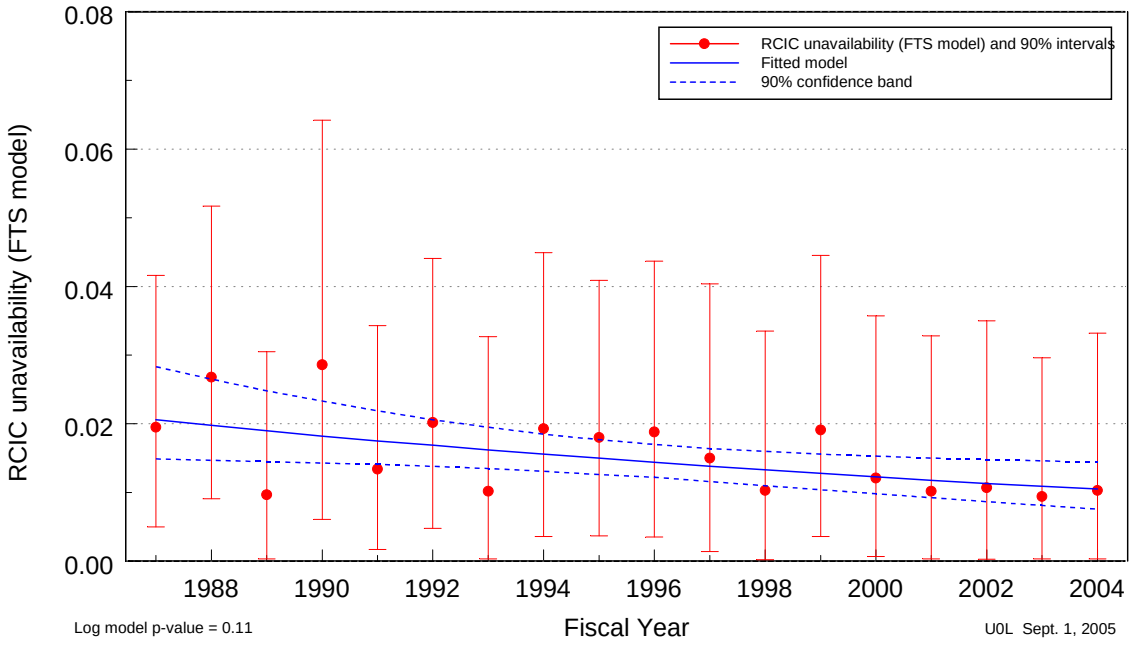

Figure 1. Trend of RCIC system unavailability (FTS model), as a function of fiscal year.

The leading contributor to RCIC system short-term unavailability is the failure of the turbine to start. Figure 2 shows the distribution of segment failure contributions for the FTS model.

[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).

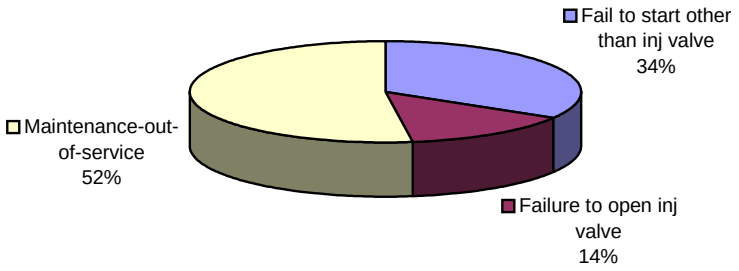

Figure 2. Segment failure distribution, FTS model.

1.3 Fail to Operate for 8-Hour Model

Individual plant result unreliability has been calculated for the 8-hour mission. The current data set identified differences between earlier (1986 to 1995) and later (1996 to 2004) data for the fail-to-start injection (decreased) and the probability of multiple injection (increased) failure modes. The later data set does not show plant to plant differences in the data. Therefore, the waterfall chart for plant differences is not shown.

No statistically significant trend within the industry estimates of RCIC system unreliability (8-hour mission) on a per fiscal year basis was identified. Figure 3 displays the trend by fiscal year of the RCIC system unreliability calculated from the 1987–2004 experience. Table 6 shows the data points for Figure 3.

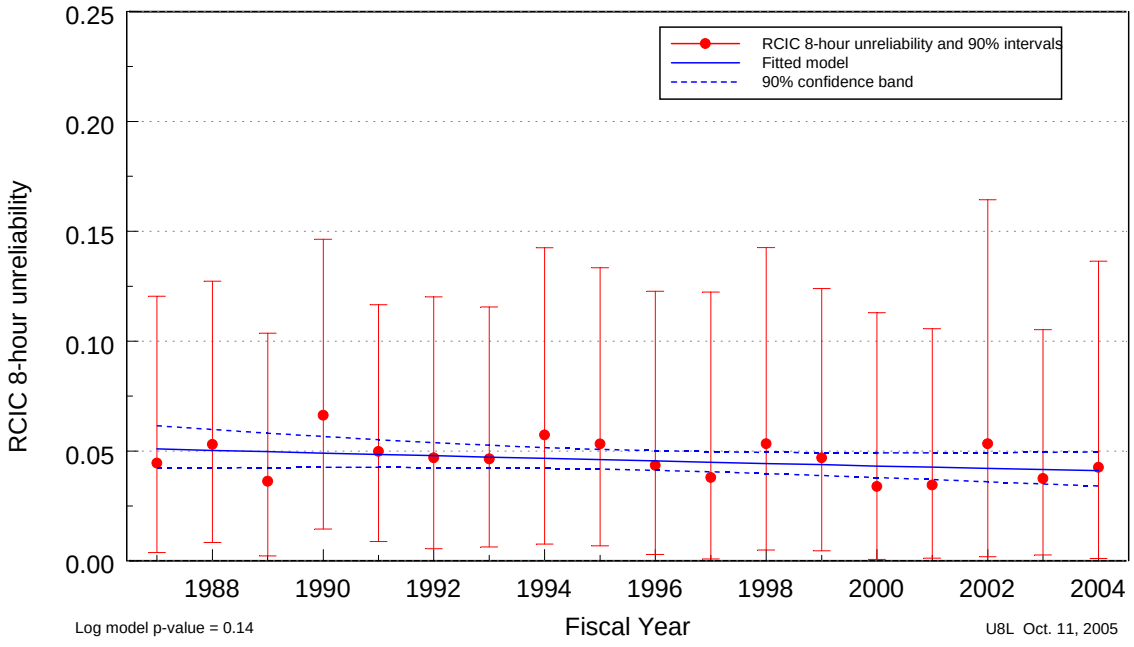

Figure 3. Trend of RCIC system unreliability (8-hour mission), as a function of fiscal year.

The leading segment failure contributor to the RCIC system unreliability is the failure to run of the pump and turbine. Figure 4 shows the distribution of segment failures for the 8-hour mission.

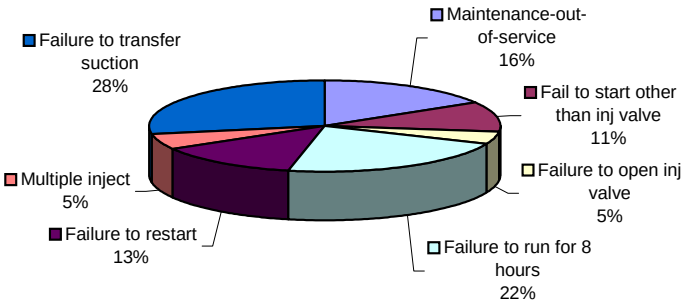

Figure 4. Segment failure distribution, 8-hour mission.

2 DATA TRENDS

The raw actuation and failure data were trended for event counts over time.

2.1 Unplanned Demand Trend

Trends were identified in the frequency of RCIC unplanned demands (Figure 5). When modeled as a function of fiscal year, the unplanned demand frequency exhibited an extremely statistically significant decreasing trend. Table 7 shows the LERs that are represented in the figure.

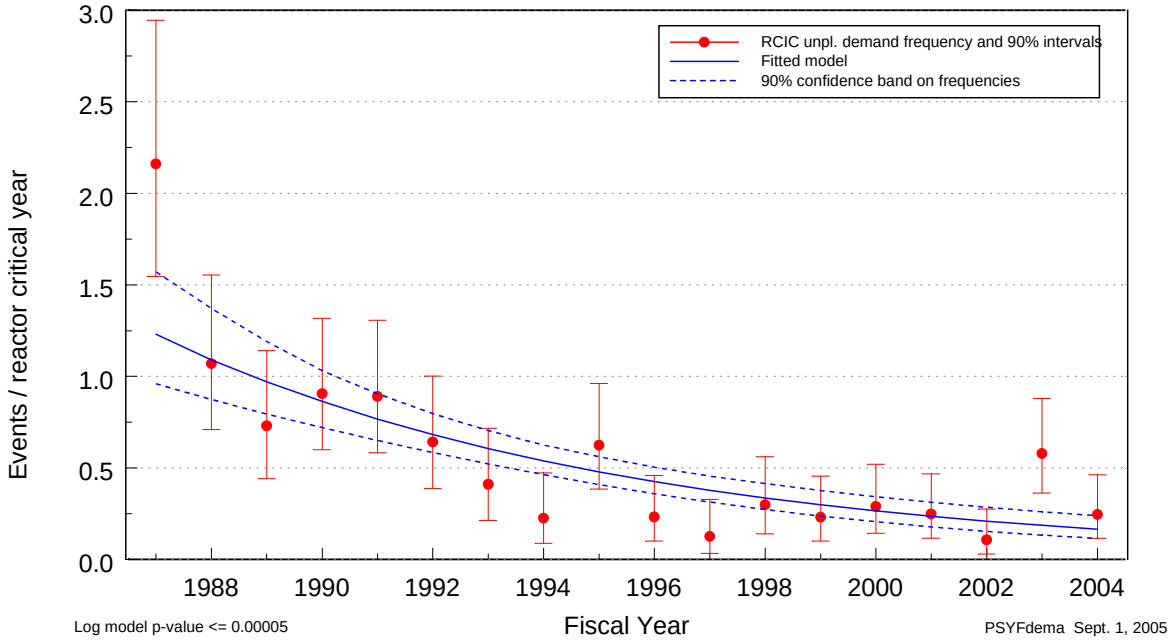

Figure 5. Frequency (events per operating year) of unplanned demands, as a function of fiscal year.

2.2 Failure Trend

The frequency of all failures (unplanned demands, surveillance tests, inspections, etc.) resulting in train unavailability identified in the experience was analyzed to determine trends. When modeled as a function of fiscal year, an extremely statistically significant decreasing trend was identified. The fitted frequency is plotted against fiscal year in Figure 6. Trends for RCIC failures are plotted without regard to method of detection (the trend excludes maintenance out of service, support system failures, and containment isolation failures). Table 8 shows the LERs that are represented in the figure.

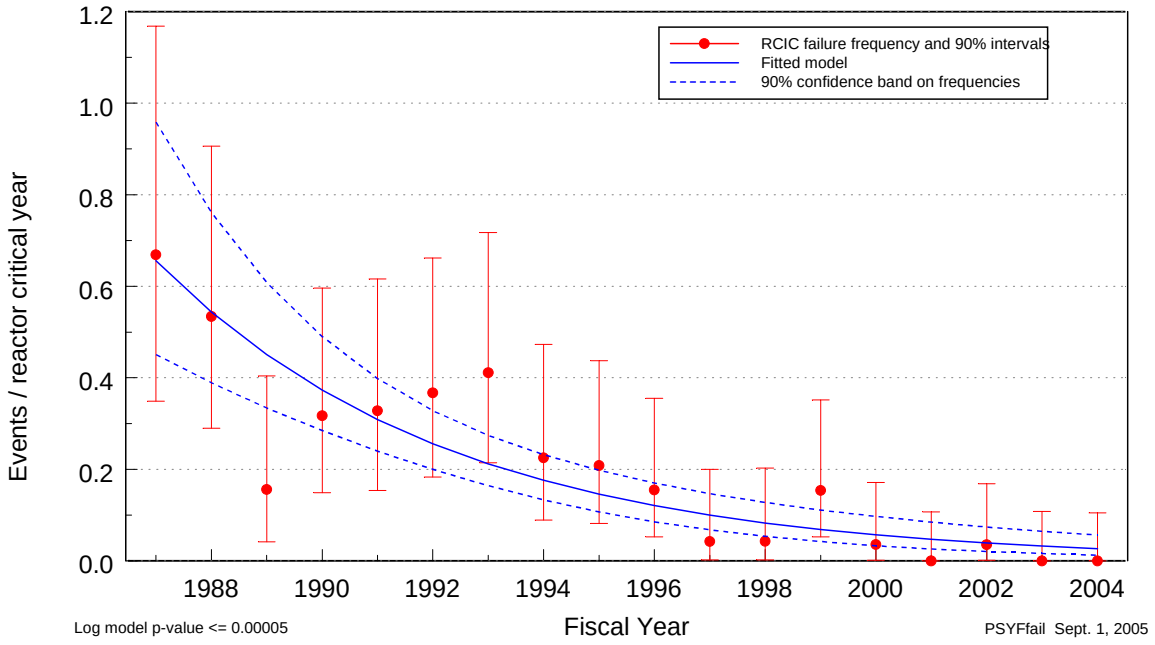

Figure 6. Frequency (events per operating year) of failures, as a function of fiscal year.

2.3 Failure Cause and Discovery Method Summary

The raw failure data were sliced to show the distribution of the failure causes and the discovery methods by the affected segment.

2.3.1 Leading Segment Failures.

The steam supply (26%) and the turbine and turbine control (30%) were the leading segment failures identified in the database. See Table 2.

2.3.2 Leading Discovery Methods

Periodic surveillance (29%) and unplanned demand (24%) were the leading methods of discovery. See Table 2.

2.3.3 Leading Causes of Failure.

Seventy-two percent of the failures of the RCIC system observed in the experience were attributed to hardware-related problems. Personnel errors caused 16% of all RCIC system failures. However, half of these failures were immediately identified, meaning that the failures were of the nature where plant personnel were able to respond to the failures immediately after they occurred. See Table 4

Table 2. Comparison of failed segment with the method of discovery.[2]

Segment	Actual/ unplanned demand	Alarm/ indicator	I&C functional test	Inspection/ review	Other (not counted) surveillance test	Periodic surveillance on system	Post-maintenance testing	Unscheduled TS required surveillance	Total	Percent
Electrical	1	2					1		4	5%
HVAC				1					1	1%
I&C	2		2	2		1			7	9%
Injection (Discharge)	5			1		3	1	1	11	14%
Injection (Suction)						1			1	1%
Lube Oil						2		1	3	4%
Service Water		1							1	1%
Steam Supply	4	2	3	2	1	2	4	2	20	26%
Turbine & Turbine Control	4			4		10	3	2	23	30%
Turbine Exhausts & drains	2					3			5	7%
Total	18	5	5	10	1	22	9	6	76	100%
	24%	7%	7%	13%	1%	29%	12%	8%	100%	

Table 3. Discovery method description.

Discovery Method	Description	Used in the Failure Calculations
Actual/unplanned demand	The demand for the system was ESF, inadvertent. If the demand was inadvertent, the demand should mimic an ESF demand.	✓
Design review	Because of a design review, a deficiency was noted in the system.	

[2] The discovery method is the activity that is ongoing at the time of the failure.

Discovery Method	Description	Used in the Failure Calculations
Periodic surveillance on subject system	Normally scheduled surveillance. These surveillances are to satisfy scheduled Technical Specification requirements.	✓
Maintenance on subject system	The failed condition was discovered during maintenance on the system. These include latent failures as well as maintenance-induced failures.	
Inspection/review	The failure was discovered during operator duties such as walk downs, inspections, etc.	
Alarm/indicator	The failure was evidenced by an alarm or by other indications.	
I&C functional test	The failure was discovered during testing of the instrumentation and control system for the subject system or another system.	
Post-maintenance testing	Failed condition was discovered during post-maintenance testing. The technical specification surveillance tests can be used for this testing, but cannot be counted.	
Unscheduled TS required surveillance	Failed condition was discovered during technical specification required testing. Tests are performed to show system operability per the technical specifications and are not scheduled. The technical specification surveillance tests can be used for this testing, but cannot be counted.	
Other (not counted) surveillance test	All others discovered by testing.	

Table 4. Comparison of failed segment and failure cause.[3]

Segment	Contamination	Design	Hardware	Personnel	Procedure	Total	Percent
Electrical		1	3			4	5%
HVAC			1			1	1%
I&C			3	4		7	9%
Injection (Discharge)		1	8	1	1	11	14%
Injection (Suction)					1	1	1%
Lube Oil	1	1		1		3	4%
Service Water			1			1	1%
Steam Supply			19	1		20	26%
Turbine & Turbine Control			18	4	1	23	30%
Turbine Exhausts & drains	1	1	2	1		5	7%
Total	2	4	55	12	3	76	100%
	3%	5%	72%	16%	4%	100%	

- Contamination–The failure was the result of foreign material affecting the component.
- Design–The failure was the result of a flawed design.
- Hardware–The failure was the result of some aspect of the equipment. Typically, this is used for normal wear of the component.
- Personnel–The failure was the result of personnel error, by either commission or omission.
- Procedure–The failure was the result of an incorrect procedure.

[3] The cause of the failure is assigned to a broadly defined cause classification. The cause classifications are design, environment, hardware (e.g., aging, wear, manufacturing defects), personnel, and procedure. The cause classification assigned is based on the immediate cause of the failure and not the root cause. Generally, root cause is only determined through a detailed investigation and analysis of the failure. Specifically, the mechanism that actually resulted in the failure of the segment or component is captured as the cause.

3 DATA TABLES

3.1 Data Tables for Unreliability and Unavailability Trends

Table 5. Plot data table for RCIC system unavailability, FTS model, Figure 1.

	Plot Trend Error Bar Points			Regression Curve Data Points		
Fiscal Year	Lower (5%)	Mean	Upper (95%)	Lower (5%)	Mean	Upper (95%)
1987	5.00E-03	1.95E-02	4.16E-02	1.61E-02	2.12E-02	2.64E-02
1988	9.11E-03	2.68E-02	5.17E-02	1.58E-02	2.06E-02	2.53E-02
1989	3.30E-04	9.68E-03	3.05E-02	1.56E-02	1.99E-02	2.42E-02
1990	6.09E-03	2.86E-02	6.43E-02	1.53E-02	1.93E-02	2.32E-02
1991	1.67E-03	1.34E-02	3.42E-02	1.50E-02	1.86E-02	2.22E-02
1992	4.74E-03	2.02E-02	4.41E-02	1.47E-02	1.79E-02	2.12E-02
1993	2.93E-04	1.02E-02	3.27E-02	1.43E-02	1.73E-02	2.03E-02
1994	3.63E-03	1.93E-02	4.49E-02	1.38E-02	1.66E-02	1.94E-02
1995	3.70E-03	1.80E-02	4.08E-02	1.33E-02	1.60E-02	1.87E-02
1996	3.58E-03	1.88E-02	4.37E-02	1.26E-02	1.53E-02	1.80E-02
1997	1.46E-03	1.50E-02	4.04E-02	1.18E-02	1.47E-02	1.75E-02
1998	2.76E-04	1.03E-02	3.35E-02	1.10E-02	1.40E-02	1.70E-02
1999	3.53E-03	1.91E-02	4.45E-02	1.01E-02	1.33E-02	1.66E-02
2000	6.71E-04	1.21E-02	3.57E-02	9.11E-03	1.27E-02	1.63E-02
2001	2.88E-04	1.02E-02	3.27E-02	8.10E-03	1.20E-02	1.60E-02
2002	2.62E-04	1.07E-02	3.50E-02	7.05E-03	1.14E-02	1.57E-02
2003	3.23E-04	9.43E-03	2.97E-02	5.97E-03	1.07E-02	1.55E-02
2004	2.85E-04	1.03E-02	3.32E-02	4.88E-03	1.01E-02	1.52E-02

Table 6. Plot data table for RCIC system unreliability, 8-hour mission, Figure 3.

	Plot Trend Error Bar Points			Regression Curve Data Points		
Fiscal Year	Lower (5%)	Mean	Upper (95%)	Lower (5%)	Mean	Upper (95%)
1987	3.92E-03	4.45E-02	1.20E-01	4.28E-02	5.15E-02	6.03E-02
1988	8.40E-03	5.30E-02	1.27E-01	4.29E-02	5.09E-02	5.89E-02
1989	2.35E-03	3.63E-02	1.04E-01	4.30E-02	5.03E-02	5.77E-02
1990	1.44E-02	6.63E-02	1.46E-01	4.31E-02	4.98E-02	5.64E-02
1991	8.84E-03	4.98E-02	1.17E-01	4.31E-02	4.92E-02	5.52E-02
1992	5.51E-03	4.69E-02	1.20E-01	4.31E-02	4.86E-02	5.41E-02
1993	6.39E-03	4.65E-02	1.16E-01	4.29E-02	4.80E-02	5.31E-02
1994	7.65E-03	5.73E-02	1.42E-01	4.27E-02	4.74E-02	5.22E-02
1995	6.87E-03	5.32E-02	1.33E-01	4.22E-02	4.68E-02	5.14E-02
1996	3.00E-03	4.35E-02	1.23E-01	4.17E-02	4.62E-02	5.08E-02
1997	9.74E-04	3.80E-02	1.22E-01	4.09E-02	4.57E-02	5.04E-02
1998	4.97E-03	5.34E-02	1.43E-01	4.00E-02	4.51E-02	5.01E-02
1999	4.73E-03	4.69E-02	1.24E-01	3.90E-02	4.45E-02	5.00E-02
2000	6.33E-04	3.39E-02	1.13E-01	3.79E-02	4.39E-02	4.99E-02
2001	1.37E-03	3.45E-02	1.06E-01	3.67E-02	4.33E-02	4.99E-02
2002	1.93E-03	5.34E-02	1.64E-01	3.54E-02	4.27E-02	5.00E-02
2003	2.70E-03	3.75E-02	1.05E-01	3.41E-02	4.21E-02	5.01E-02
2004	1.12E-03	4.26E-02	1.36E-01	3.28E-02	4.15E-02	5.03E-02

3.2 Data Tables for Failure and Demand Trends

Table 7. LER listing for demand trend figure.
Figure 5

FY	Plant Name	LER	Event Date
1997	Browns Ferry 2	2601997001	4/24/1997
1996	Browns Ferry 3	2961996002	4/21/1996
1996	Browns Ferry 3	2961996003	5/1/1996
2000	Browns Ferry 3	2962000001	4/15/2000
2000	Browns Ferry 3	2962000005	5/24/2000
1987	Brunswick 1	3251987019	7/1/1987
1991	Brunswick 1	3251991018	7/18/1991
1992	Brunswick 1	3251992003	1/17/1992
1992	Brunswick 1	3251992005	2/29/1992
1995	Brunswick 1	3251995015	7/13/1995
1995	Brunswick 1	3251995018	9/30/1995
2004	Brunswick 1	3252004002	8/14/2004
1987	Brunswick 2	3241987001	1/5/1987
1987	Brunswick 2	3241987004	3/11/1987
1989	Brunswick 2	3241988018	11/16/1988
1989	Brunswick 2	3241989009	6/17/1989
1990	Brunswick 2	3241990008	8/16/1990
1990	Brunswick 2	3241990009	8/19/1990
1990	Brunswick 2	3241990015	9/27/1990
1991	Brunswick 2	3241990016	10/12/1990
1991	Brunswick 2	3241991001	1/25/1991
1992	Brunswick 2	3241992001	2/2/1992
2003	Brunswick 2	3242003003	4/4/2003
2004	Brunswick 2	3242003004	11/4/2003
1988	Clinton 1	4611988019	7/12/1988
1989	Clinton 1	4611989029	7/14/1989
2000	Clinton 1	4612000001	5/17/2000
1987	Columbia 2	3971987002	3/22/1987
1987	Columbia 2	3971987020	7/2/1987
1987	Columbia 2	3971987022	7/6/1987
1988	Columbia 2	3971988003	2/4/1988
1988	Columbia 2	3971988006	2/13/1988
1993	Columbia 2	3971993027	8/3/1993
1995	Columbia 2	3971995002	2/18/1995
1998	Columbia 2	3971998003	3/11/1998
1998	Columbia 2	3971998002	3/11/1998
2004	Columbia 2	3972004005	8/15/2004
2004	Columbia 2	3972004006	8/17/2004
1987	Cooper	2981987003	1/7/1987
1987	Cooper	2981987006	1/10/1987
1987	Cooper	2981987009	2/18/1987
1987	Cooper	2981987011	5/17/1987
1988	Cooper	2981988021	8/25/1988
1990	Cooper	2981989026	11/25/1989
1991	Cooper	2981990011	10/17/1990
1994	Cooper	2981993038	12/14/1993
1994	Cooper	2981994004	3/2/1994
1996	Cooper	2981995012	10/14/1995
2001	Cooper	2982001002	3/3/2001
2003	Cooper	2982003004	5/26/2003
2004	Cooper	2982003007	11/26/2003
1989	Duane Arnold	3311989008	3/5/1989
1989	Duane Arnold	3311989011	8/26/1989
1990	Duane Arnold	3311990002	3/29/1990
1991	Duane Arnold	3311990019	10/19/1990
2002	Duane Arnold	3312001006	10/17/2001
1987	Fermi 2	3411987017	5/13/1987
1987	Fermi 2	3411987025	6/25/1987
1988	Fermi 2	3411988004	1/10/1988
1993	Fermi 2	3411992012	11/18/1992
1993	Fermi 2	3411993010	8/13/1993
1995	Fermi 2	3411995004	4/9/1995
2003	Fermi 2	3412003002	8/14/2003
1987	FitzPatrick	3331987008	6/10/1987
1990	FitzPatrick	3331989020	11/5/1989
1990	FitzPatrick	3331990009	3/19/1990
1993	FitzPatrick	3331993009	4/20/1993
1995	FitzPatrick	3331995013	9/5/1995
1996	FitzPatrick	3331996010	9/16/1996
1998	FitzPatrick	3331998008	8/3/1998
2000	FitzPatrick	3331999010	10/14/1999
2003	FitzPatrick	3332003001	8/14/2003
1988	Grand Gulf	4161988006	1/20/1988
1989	Grand Gulf	4161989006	5/5/1989
1989	Grand Gulf	4161989010	7/22/1989
1989	Grand Gulf	4161989012	8/14/1989
1990	Grand Gulf	4161989019	12/30/1989
1990	Grand Gulf	4161990011	7/24/1990
1990	Grand Gulf	4161990017	9/16/1990
1991	Grand Gulf	4161990028	12/10/1990
1991	Grand Gulf	4161990029	12/18/1990
1991	Grand Gulf	4161991004	6/11/1991
1991	Grand Gulf	4161991005	6/17/1991
1991	Grand Gulf	4161991007	7/28/1991
1992	Grand Gulf	4161992013	6/18/1992
1995	Grand Gulf	4161995007	7/3/1995
1995	Grand Gulf	4161995008	7/12/1995
1998	Grand Gulf	4161998001	1/28/1998
1999	Grand Gulf	4161999003	2/21/1999
2000	Grand Gulf	4162000005	9/15/2000
2001	Grand Gulf	4162001003	8/7/2001
2003	Grand Gulf	4162003002	4/24/2003
1987	Hatch 1	3211987013	8/3/1987
1988	Hatch 1	3211988013	9/4/1988
1989	Hatch 1	3211988018	12/17/1988
1990	Hatch 1	3211990013	6/20/1990
1991	Hatch 1	3211990021	10/15/1990
1991	Hatch 1	3211991001	1/18/1991
1991	Hatch 1	3211991017	9/11/1991
1992	Hatch 1	3211992021	8/27/1992
1992	Hatch 1	3211992024	9/30/1992
1994	Hatch 1	3211993013	10/22/1993
1994	Hatch 1	3211993016	12/7/1993
1996	Hatch 1	3211996009	5/26/1996
2000	Hatch 1	3212000002	1/26/2000
2000	Hatch 1	3212000011	9/29/2000
1987	Hatch 2	3661987003	1/26/1987
1987	Hatch 2	3661987008	4/22/1987
1987	Hatch 2	3661987006	7/26/1987

FY	Plant Name	LER	Event Date
1987	Hatch 2	3661987009	8/3/1987
1988	Hatch 2	3661988008	3/21/1988
1988	Hatch 2	3661988011	4/17/1988
1988	Hatch 2	3661988020	8/5/1988
1989	Hatch 2	3661989005	9/3/1989
1990	Hatch 2	3661990001	1/12/1990
1991	Hatch 2	3661991004	2/14/1991
1992	Hatch 2	3661992009	6/25/1992
1994	Hatch 2	3661994007	8/30/1994
1995	Hatch 2	3661995001	4/11/1995
1997	Hatch 2	3661997007	4/22/1997
1998	Hatch 2	3661997010	11/20/1997
1999	Hatch 2	3661999006	6/15/1999
1987	Hope Creek	3541987017	2/24/1987
1987	Hope Creek	3541987034	7/30/1987
1987	Hope Creek	3541987037	8/16/1987
1987	Hope Creek	3541987039	8/29/1987
1988	Hope Creek	3541988012	4/30/1988
1989	Hope Creek	3541988027	10/15/1988
1989	Hope Creek	3541988029	11/1/1988
1990	Hope Creek	3541990003	3/19/1990
1992	La Salle 1	3731992003	3/1/1992
1993	La Salle 1	3731993015	9/14/1993
1992	La Salle 2	3741992012	8/27/1992
1995	La Salle 2	3741994008	10/19/1994
1995	La Salle 2	3741994010	12/14/1994
1995	La Salle 2	3741995001	1/12/1995
2001	La Salle 2	3742001001	4/6/2001
2001	La Salle 2	3742001003	9/3/2001
2003	La Salle 2	3742003004	7/7/2003
1987	Limerick 1	3521987048	9/19/1987
1991	Limerick 1	3521991009	4/12/1991
1999	Limerick 1	3521999003	4/20/1999
2003	Limerick 1	3522003003	4/23/2003
1990	Limerick 2	3531990015	9/10/1990
1995	Limerick 2	3531994010	10/19/1994
1995	Limerick 2	3531995008	8/8/1995
1987	Monticello	2631987009	4/3/1987
1991	Monticello	2631991019	8/25/1991
1988	Nine Mile Pt. 2	4101988001	1/20/1988
1988	Nine Mile Pt. 2	4101988012	3/5/1988
1988	Nine Mile Pt. 2	4101988014	3/13/1988
1989	Nine Mile Pt. 2	4101989014	4/13/1989
1991	Nine Mile Pt. 2	4101991017	8/13/1991
1992	Nine Mile Pt. 2	4101991023	12/12/1991
1999	Nine Mile Pt. 2	4101999005	4/24/1999
1999	Nine Mile Pt. 2	4101999010	6/24/1999
2000	Nine Mile Pt. 2	4102000002	3/3/2000
2003	Nine Mile Pt. 2	4102002004	11/11/2002
2003	Nine Mile Pt. 2	4102002006	12/16/2002
2003	Nine Mile Pt. 2	4102003002	8/14/2003
1990	Peach Bottom 2	2771989033	12/20/1989
1992	Peach Bottom 2	2771992010	7/4/1992
1992	Peach Bottom 2	2771992012	7/17/1992
2003	Peach Bottom 2	2772002001	12/21/2002
2003	Peach Bottom 2	2772003004	9/15/2003
1990	Peach Bottom 3	2781990002	1/28/1990
1990	Peach Bottom 3	2781990008	7/27/1990
1993	Peach Bottom 3	2781992008	10/15/1992
2003	Peach Bottom 3	2772003004	9/15/2003
1987	Perry	4401987042	6/17/1987
1987	Perry	4401987064	9/9/1987
1988	Perry	4401987072	10/27/1987
1988	Perry	4401988012	4/27/1988
1988	Perry	4401988023	6/8/1988
1990	Perry	4401990002	1/7/1990
1992	Perry	4401992017	9/10/1992
1993	Perry	4401993010	3/26/1993
1995	Perry	4401995005	8/31/1995
1995	Perry	4401995008	9/11/1995
1997	Perry	4401997001	1/7/1997
1998	Perry	4401998002	7/1/1998
2001	Perry	4402001001	4/29/2001
2001	Perry	4402001003	7/11/2001
2003	Perry	4402003002	8/14/2003
1992	Pilgrim	2931991025	10/30/1991
1993	Pilgrim	2931993004	3/13/1993
1993	Pilgrim	2931993022	9/10/1993
1990	Quad Cities 1	2541990004	3/10/1990
1987	Quad Cities 2	2651987009	8/1/1987
1988	Quad Cities 2	2651987013	10/19/1987
2001	Quad Cities 2	2652001001	8/2/2001
1988	River Bend	4581988018	8/25/1988
1988	River Bend	4581988021	9/6/1988
1989	River Bend	4581989008	2/25/1989
2002	River Bend	4582002001	9/18/2002
2003	River Bend	4582003001	2/22/2003
2004	River Bend	4582004001	8/15/2004
1987	Susquehanna 1	3871987013	4/2/1987
1991	Susquehanna 1	3871991008	7/31/1991
1999	Susquehanna 1	3871999003	7/1/1999
2003	Susquehanna 1	3872003006	9/24/2003
2004	Susquehanna 1	3872004003	4/21/2004
1987	Susquehanna 2	3881987006	4/16/1987
1990	Susquehanna 2	3881990005	5/28/1990
1996	Susquehanna 2	3881996004	7/14/1996
1991	Vermont Yankee	2711991009	4/23/1991
1998	Vermont Yankee	2711998016	6/9/1998

Table 8. LER listing for failure trend figure.
Figure 6

FY	Plant Name	LER	Event Date
1993	Browns Ferry 2	2601993009	8/22/1993
1996	Browns Ferry 2	2601996005	5/10/1996
1988	Brunswick 1	3251988020	9/15/1988
1987	Brunswick 2	3241987001	1/5/1987
1990	Brunswick 2	3241990009	8/19/1990
1988	Columbia 2	3971988003	2/4/1988
1990	Cooper	2981990009	8/8/1990
1992	Cooper	2981992012	7/15/1992
1996	Cooper	2981996003	3/20/1996
1999	Cooper	2981998012	12/17/1998
1988	Duane Arnold	3311988001	1/11/1988
1991	Duane Arnold	3311991007	8/6/1991
2002	Duane Arnold	3312002003	8/21/2002
1990	FitzPatrick	3331989021	10/31/1989
1990	FitzPatrick	3331989024	11/29/1989
1995	FitzPatrick	3331994007	10/30/1994
1987	Hatch 1	3211987011	7/23/1987

FY	Plant Name	LER	Event Date
1989	Hatch 1	3211988018	12/17/1988
1991	Hatch 1	3211991001	1/18/1991
1988	Hatch 2	3661988017	5/27/1988
1997	Hope Creek	3541996029	12/28/1996
1998	Hope Creek	3541997032	12/5/1997
1988	La Salle 1	3731988015	7/12/1988
1990	La Salle 1	3731990007	6/18/1990
1991	La Salle 1	3731991012	7/29/1991
1992	La Salle 1	3731991017	10/23/1991
1992	La Salle 1	3731992005	4/6/1992
1993	La Salle 1	3731993003	1/29/1993
1993	La Salle 1	3731993003	1/30/1993
1993	La Salle 1	3731993004	2/10/1993
1993	La Salle 1	3731993007	2/26/1993
1995	La Salle 1	3731994013	11/14/1994
1991	La Salle 2	3741991005	6/21/1991
1992	La Salle 2	3741992010	8/10/1992
1992	La Salle 2	3741992012	8/27/1992
1993	La Salle 2	3741993006	8/18/1993
1994	La Salle 2	3741993010	12/25/1993
1994	La Salle 2	3741994002	2/21/1994
1989	Monticello	2631989006	4/14/1989
1999	Monticello	2631999004	4/22/1999
1999	Nine Mile Pt. 2	4101999005	4/24/1999
2000	Nine Mile Pt. 2	4102000002	3/3/2000
1987	Perry	4401987003	1/10/1987
1987	Perry	4401987003	1/10/1987
1987	Perry	4401987003	1/10/1987
1987	Perry	4401987003	1/10/1987
1987	Perry	4401987012	3/2/1987

FY	Plant Name	LER	Event Date
1987	Perry	4401987040	6/4/1987
1990	Pilgrim	2931990013	9/2/1990
1992	Pilgrim	2931991025	10/30/1991
1993	Pilgrim	2931992015	11/25/1992
1993	Pilgrim	2931993002	2/25/1993
1993	Pilgrim	2931993013	5/30/1993
1994	Pilgrim	2931994004	8/3/1994
1994	Pilgrim	2931994004	8/3/1994
1995	Pilgrim	2931995002	2/2/1995
1996	Pilgrim	2931995011	12/6/1995
1996	Pilgrim	2931996003	4/3/1996
1988	Quad Cities 1	2541987032	12/23/1987
1988	Quad Cities 1	2541988003	1/25/1988
1988	Quad Cities 1	2541988011	6/25/1988
1988	Quad Cities 1	2541988013	8/22/1988
1989	Quad Cities 1	2541989001	1/6/1989
1990	Quad Cities 1	2541990005	3/13/1990
1991	Quad Cities 1	2541991029	4/24/1991
1991	Quad Cities 1	2541991018	9/13/1991
1992	Quad Cities 1	2541992005	12/1/1991
1995	Quad Cities 1	2541995001	1/2/1995
1987	Quad Cities 2	2651987009	8/1/1987
1992	Quad Cities 2	2651992015	5/12/1992
1999	Quad Cities 2	2651999003	8/25/1999
1994	River Bend	4581994023	9/8/1994
1988	Vermont Yankee	2711987018	11/14/1987
1991	Vermont Yankee	2711991009	4/23/1991
1995	Vermont Yankee	2711995006	5/2/1995