Operating Experience Data and Data Analysis

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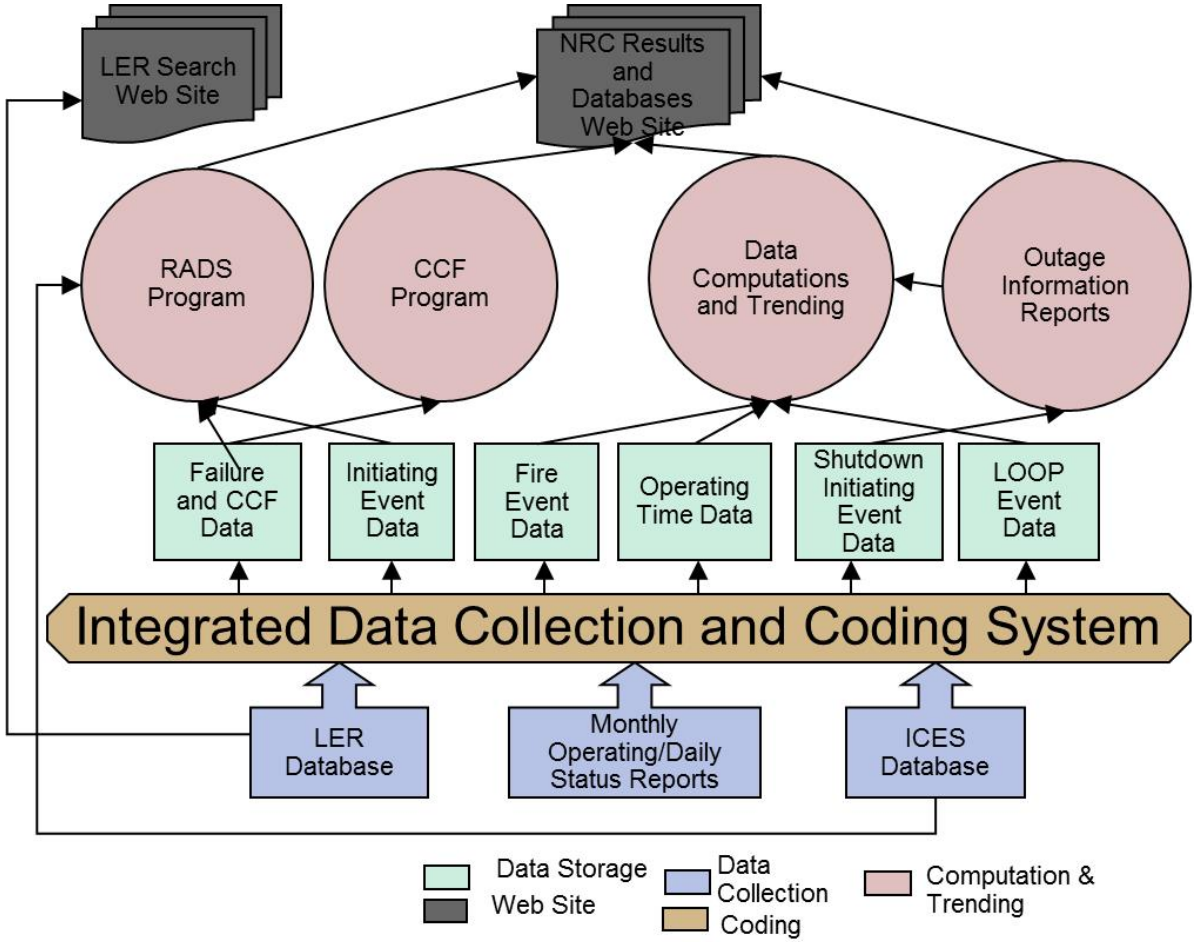
July 14, 2015

Introduction

- Data sources
- Data processing
- Data products
- Overview of the NRC Reactor Operating Experience Data (NROD) web site

Data Program Overview



Data Processing

- Data Entry
  - New Licensee Event Report (LER) records are logged into LER Track database and added to the Integrated Data Collection and Coding System (IDCCS) document log.
  - New Institute for Nuclear Power Operations (INPO) Consolidated Events Database (ICES) records added to IDCCS document log after screening for interest (devices).
  - IDCCS identifies new LER and ICES records
  - IDCCS coding personnel open and read each LER and ICES record and review for applicability to the studies
- Some products are only dependent on LERs
  - Initiating Events
  - Loss of Offsite Power (LOOP)
  - Shutdown Initiating Events
  - Performance Indicators (PI) Actuation and Failure

Data Processing (cont.)

- The rest are dependent on both LERs and ICES information.
  - Failure
  - Fire
  - Relief Valve Demands
  - Common Cause Failure data (CCF)
- Where both an LER and an ICES document apply to the same event, it is identified with a link to both.
- One document can also apply to more than one study (e.g., equipment failure and an initiating event).
- The document may be identified as not applying to any study.

Data Processing (cont.)

- IDCCS data subject to quality assurance process:
  - A user's guide describes each study and provides guidance for filling out each field in the IDCCS.
  - The IDCCS program utilizes numerous lookup tables and automated checks to ensure data consistency.
  - Records are entered by qualified coding engineers.
  - Each record is independently checked by a second qualified coding engineer.
  - The IDCCS software randomly selects a sample of records for an independent quality review semi-annually.

Data Processing (cont.)

- Un-reviewed data
  - Unavailability
  - Run hours and demands
  - Device failures not included in the INL capture list. These devices typically reside in non-safety systems.
- Calculations are performed on selected groups of data using several programs generally implementing methods from NUREG/CR-6823.
  - Initiating event trends using Statistical Analysis Software (SAS)
  - System and component unreliability using the SPAR models, Reliability and Availability Data System (RADS) software, spreadsheets, and custom software in R, Visual Basic, and C#.
  - Common cause failure parameter estimates using CCF software (web based).
  - Industry average parameter estimates using RADS software (web based).

Data Products

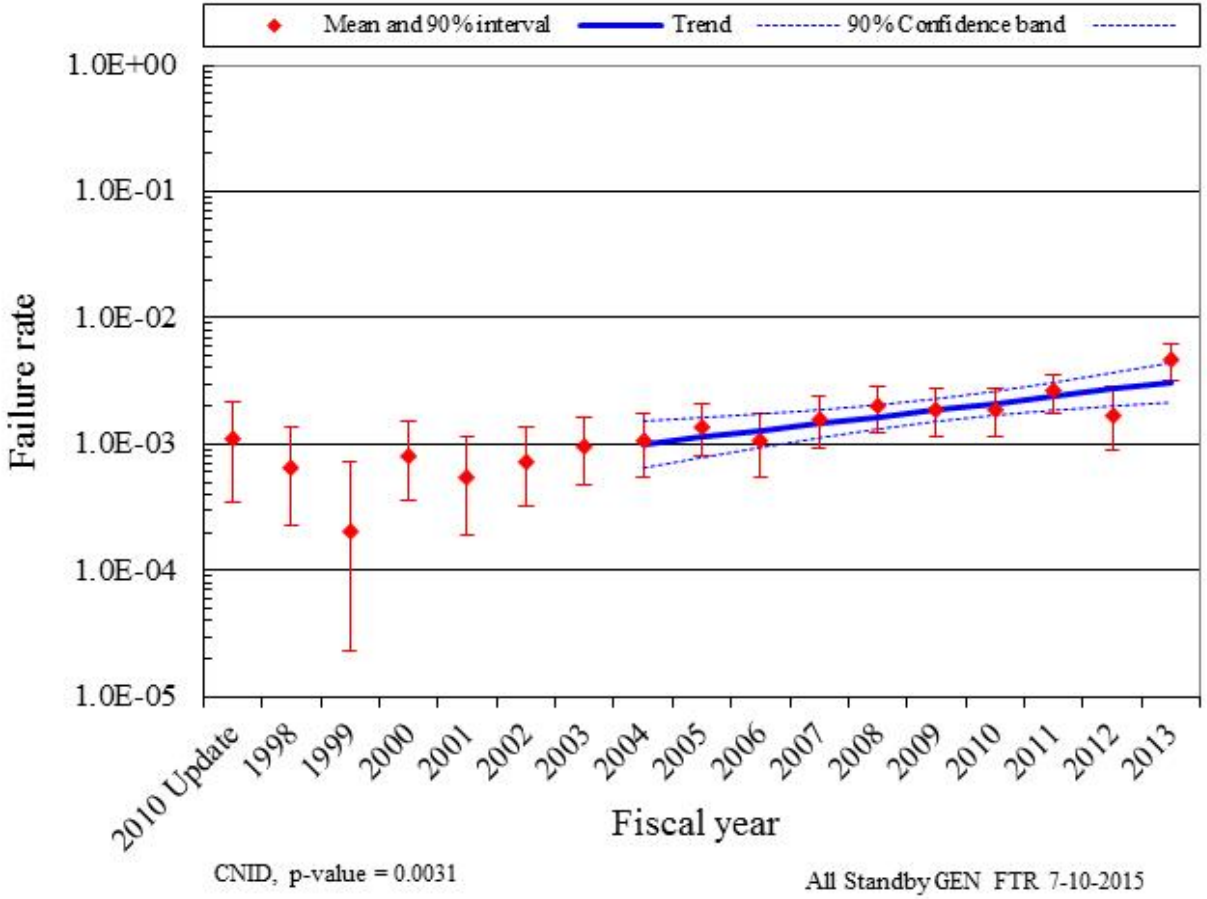
- Annual Updates
  - System Studies
    - Auxiliary feed water
    - Emergency power
    - High pressure coolant injection
    - High pressure core spray
    - High pressure injection
    - Isolation condenser
    - Reactor core isolation cooling
    - Residual heat removal

Data Products (cont.)

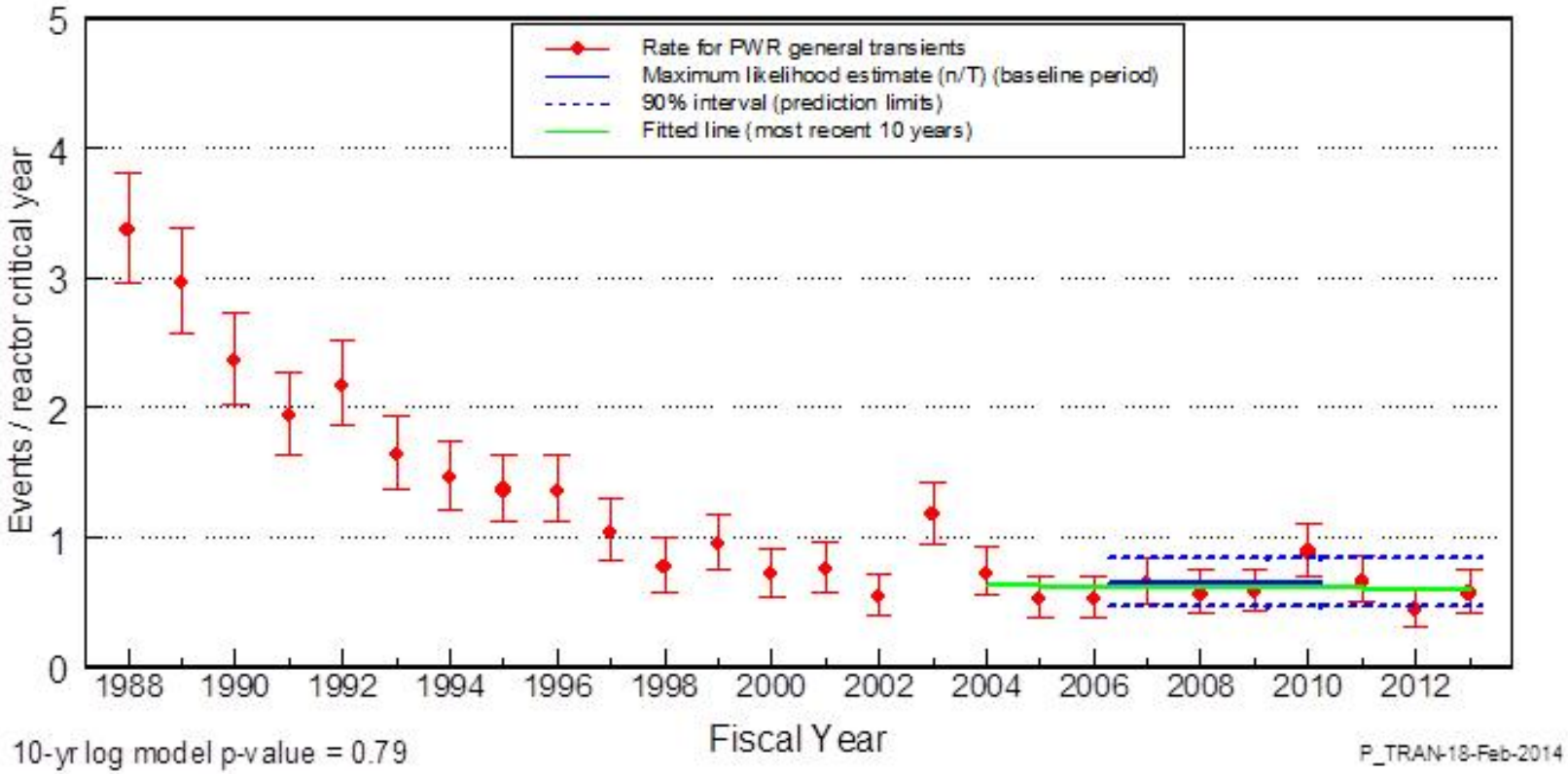
- Component Performance
  - Air operated valves
  - Emergency diesel generators
  - Motor driven pumps
  - Motor operated valves
  - Turbine driven pumps
- Initiating Event
- Fire
- LOOP
  - Frequencies
  - Recovery curves
- Operating Time

- Parameter estimates for SPAR failure rates and common cause failure model alpha factors.

Example: EDG Failure Rate Trend



Example: PWR General Transient Initiating Event Frequency Trend



Example: SPAR Model Data (NUREG/CR-6928) Updates

	Initiating Event	Description	DataSource	Data		Industry-average Frequency Distribution (note a)				
				Number of Events	Critical Years (rcry)	Distribution (note b)	Mean	α	β	Error Factor
TRANSIENTS	Loss of Feedwater									
	IE-LOMFW	Loss of Main Feedwater	IEDB	113	1638.768	Gamma	6.89E-02	2.2	32.2	2.7
	General Transients									
	IE-TRANS (BWR)	General Transient (BWR)	IEDB	332	437.264	Gamma	7.62E-01	21.0	27.6	1.4
	IE-TRANS (PWR)	General Transient (PWR)	IEDB	553	803.884	Gamma	6.90E-01	8.2	11.9	1.7
	Loss of Condenser Heat Sink									
	IE-LOCHS (BWR)	Loss of Condenser Heat Sink (BWR)	IEDB	65	465.633	Gamma	1.39E-01	2.9	20.9	2.4
	IE-LOCHS (PWR)	Loss of Condenser Heat Sink (PWR)	IEDB	57	974.689	Gamma	5.86E-02	3.7	63.8	2.2
HEAT SINK	Loss of Support Systems									
	Loss of Cooling Water									
	IE-LOSWS	Loss of Service Water System	IEDB	0	2035.66	Gamma	2.46E-04	0.5	2035.7	8.4
	IE-PLOSWS	Partial Loss of Service Water System	IEDB	3	2035.66	Gamma	1.72E-03	3.5	2035.7	2.2
	IE-LOCCW	Loss of Component Cooling Water	IEDB	0	2035.66	Gamma	2.46E-04	0.5	2035.7	8.4
	IE-PLOCCW	Partial Loss of Component Cooling Water	IEDB	4	2035.66	Gamma	2.21E-03	4.5	2035.7	2.0
LOIA	Loss of Instrument Air									
	IE-LOIA (BWR)	Loss of Instrument Air (BWR)	IEDB	4	600.403	Gamma	7.49E-03	4.5	600.4	2.0
	IE-LOIA (PWR)	Loss of Instrument Air (PWR)	IEDB	7	856.757	Gamma	8.22E-03	0.4	46.6	12.2
ELECTRICAL POWER	Loss of Electrical Bus									
	IE-LOAC	Loss of AC Bus	IEDB	11	1722.354	Gamma	6.68E-03	11.5	1722.4	1.6
	IE-LOAC 4160V	Loss of 4160V AC Bus	IEDB	7	1722.354	Gamma	4.35E-03	7.5	1722.4	1.7
	IE-LOAC LOWV	Loss of Low Voltage AC Bus	IEDB	4	1722.354	Gamma	2.61E-03	4.5	1722.4	2.0
	IE-LOAC-Calc					Gamma	3.34E-03	0.3	89.8	18.8
	IE-LODC	Loss of DC Bus	IEDB	1	2035.66	Gamma	7.37E-04	1.5	2035.7	3.3
	IE-LODC-Calc					Gamma	3.69E-04	0.3	814.1	18.8
	Loss of Offsite Power									
	Critical Operation									
	IE-LOOP	Loss of Offsite Power	IEDB	37	1421.4	Gamma	6.14E-02	1.6	25.7	3.0
	IE-LOOPGR	Grid Related Contribution to LOOP	IEDB	14	1294	Gamma	1.22E-02	0.4	32.4	11.6
	IE-LOOPPC	Plant Centered Contribution to LOOP	IEDB	2	1294	Gamma	1.93E-03	2.5	1294.0	2.5
	IE-LOOPSC	Switchyard Centered Contribution to LOOP	IEDB	13	1294	Gamma	1.04E-02	13.5	1294.0	1.5
	IE-LOOPWR	Weather Related Contribution to LOOP	IEDB	8	2171.4	Gamma	3.91E-03	8.5	2171.4	1.7
	Shutdown Operation									
	IE-SD-LOOP	Loss of Offsite Power	IEDB	54	316.6	Gamma	1.69E-01	4.2	24.9	2.2
	IE-SD-LOOPGR	Grid Related Contribution to LOOP	IEDB	5	435.9	Gamma	1.26E-02	5.5	435.9	1.9
	IE-SD-LOOPPC	Plant Centered Contribution to LOOP	IEDB	23	435.9	Gamma	5.16E-02	1.0	18.8	4.4
	IE-SD-LOOPSC	Switchyard Centered Contribution to LOOP	IEDB	10	156.5	Gamma	6.71E-02	10.5	156.5	1.6

http://nrcoe.inl.gov/resultsdb/

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PRINT

REACTOR OPERATIONAL EXPERIENCE

- Fire Protection EXIT
- Fitness-for-Duty Programs EXIT
- Access Authorization Programs EXIT
- Human Factors EXIT
- Operating Reactor Maintenance Effectiveness EXIT
- Multiple/Repetitive Degraded Cornerstone Column EXIT
- PWR Sump Performance EXIT
- Reactor Pressure Boundary Integrity Issues for Pressurized Water Reactors EXIT
- Reactor Vessel Integrity EXIT
- Steam Generator Action Plan EXIT
- Groundwater Contamination (Tritium) at Nuclear Plants EXIT
- Buried Piping Activities
- **Results and Databases**

Home > Nuclear Reactors > Operating Reactors > Operational Experience > **Results and Databases**

Reactor Operational Experience Results and Databases

This area contains updated results for a variety of previously published studies conducted by the office of Nuclear Regulatory Research.

What's New in the 2013 Update
Summary of Significant Trends for 2013
Overview and Reference

Parameter Estimates

- Industry Average Parameter Estimates
- Common-Cause Failure Parameter Estimates
- Loss of Offsite Power
- Industry Performance of Relief Valves

Trends and Insights

- Initiating Events
- System Studies
- Component Performance
- Common-Cause Failure Insights
- International Common-Cause Failures
- Fire Events

Supplemental Information

- Operating Time
- Industry Performance Data
- Other Documents
- Published Report List

SYSTEM NOTICES

2013 results are now available.

RELATED INFORMATION

- Events Assessment
- Industry Trends
- Generic Issues
- Emergency Response

Overview of the NROD Web Site

- https://nrod.inl.gov/default.aspx
- Search—Allows the searching of the INL databases using criteria such as plant type, component, date range, and many others
- EPIX Search—Word search of raw EPIX data
- PRA Calculations—Takes you to the RADS/CCF page
- Outage—Allows the user to view outage information based on selected criteria
- Reports—Shows various reports (based on data) that were developed for NRC personnel
- Documents—A collection of documents that were added to the web site. Users can suggest adding new documents.
- My Account—Review you account and see logged searches that can be re-run from there
- Help—Contains help that applies to the various functions in the NROD. The RADS/CCF help is in a separate menu item

Overview of the NROD Web Site (cont.)

- https://rads.inl.gov
- RADS Home Page
- Reliability
- Availability
- Initiating Events
- LOOP
- CCF
- Reliability Calculator
- Help

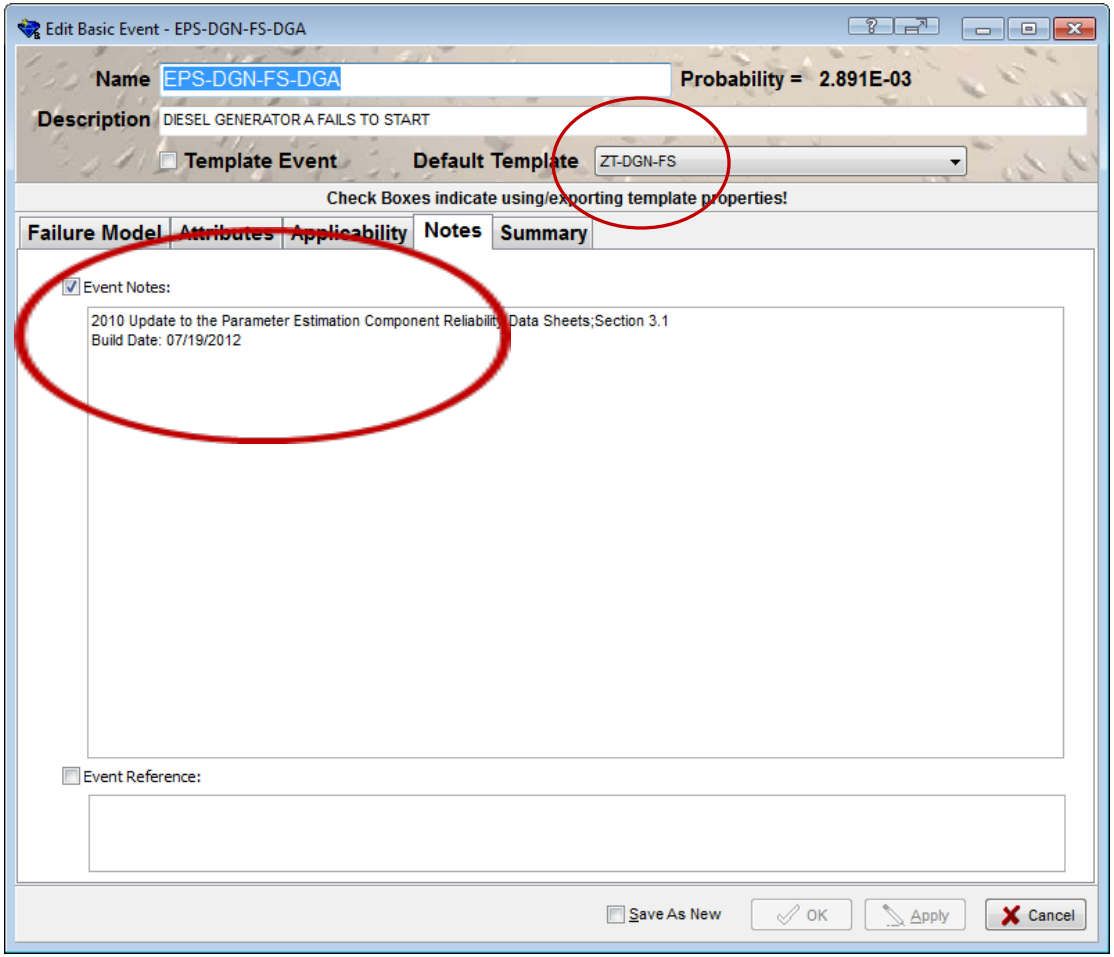
Overview of the NROD Web Site (cont.)

- The Help document is designed to answer most all of the questions on how to run the site.

- Web site provides access to detailed event information used in the SPAR models.
  - Password protected to protect proprietary information.
    - NRC access level shows all information
    - Industry access level hides proprietary information.
  - Shared rules for each SPAR template.

- Following slides demonstrate the link between SPAR model events and web site shared rules.

SPAR Basic Event Linkage to Reference



Shared Rules Example

https://rads.inl.gov/(S(rjsggmu42ed0p3vf50jfycqs))/Pages/Reliability.aspx

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PRA Data Calculations Web Site
Version 1.3.2012.1

NROD Home | RADS Home | Reliability | Availability | Initiating Events | LOOP | CCF | Reliability Calculator | Maintenance | Help

Reliability Rules
- Check Valve Leakage
- Johns Rules
- RHR MOVs
- SPAR Rules 2010
  - ABT-FF
  - ABT-SO
  - ACC-ELS
  - ACC-FTOP
  - AFW-EDP-FTR<1H
  - AFW-EDP-FTR>1H
  - AFW-EDP-FTS
  - AHU-NR-FTR
  - AHU-NR-FTS
  - AOD-FTOC
  - AOD-ILS
  - AOD-SOP
  - AOV-ELS
  - AOV-FC
  - AOV-FTC

Demands: 627.74, 483.40, 371.65, 357.71, 504.84, 547.59, 958.15, 941.76, 752.74, 574.83, 604.52, 592.76

Statistical Results for Rule: EDG-FTS | Statistical Information | General Reliability Information

Bayes Update Results | Bayes Update Chart

```
Unpartitioned Bayes Analysis for: EDG-FTS

Number of events:        158
Reactor Critical Years:  55263.8
Component Count:         224
Prior Type:              Jeffreys(a, b)
Prior Source:            Default Jeffreys Update
Prior Parameters:        0.50; 0.50

Posterior Type:          Beta(a, b)
Posterior Parameters:    158.50; 55106.30
Posterior Confidence Interval for 90% Interval:
         5th Percentile:        2.50E-03
                   Mean:        2.87E-03
        95th Percentile:        3.25E-03
Posterior Variance:      5.17E-08
Posterior Std-Dev:       2.27E-04
```

Bayesian Update Industry Result

Refresh

Entries	Dist.	Fail	Demands/Hours	a	b	lower	mean	upper
95	Beta	158	55263.8	1.59E+02	5.51E+04	2.50E-03	2.87E-03	3.25E-03

Shared Rules Result

Inbox (2) - john.schroeder | NRC: Industry-Average Pe | NRC Reactor Operating E | PRA Data Calculations We | PRA Data Calculations We

https://rads.inl.gov/(S(rjsggmu42ed0p3vf50jfycqs))/Pages/Reliability.aspx

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PRA DATA CALCULATIONS WEB SITE
VERSION 1.3.2012.1

NROD Home | RADS Home | Reliability | Availability | Initiating Events | LOOP | CCF | Reliability Calculator | Maintenance | Help

Reliability Rules | Data Analysis Options | Run Batch Reliability Rules

Analysis Type, Grouping, Date Range, and Options
Industry Average Prior
Component Characteristics
Results for rule: EDG-FTS

Refresh

Plant Name	Device Count	Failure Count	Demands
Arkansas 1	2	1	627.74
Arkansas 2	2	1	483.40
Beaver Valley 1	2	0	371.65
Beaver Valley 2	2	1	357.71
Braidwood 1	2	1	504.84
Braidwood 2	2	1	547.59
Browns Ferry 2	4	4	958.15
Browns Ferry 3	4	4	941.76
Brunswick 2	4	3	752.74
Byron 1	2	1	574.83
Byron 2	2	1	604.52
Callaway	2	3	592.76

Statistical Results for Rule: EDG-FTS | Statistical Information | General Reliability Information

Bayes Update Results | Bayes Update Chart

```
Unpartitioned Bayes Analysis for: EDG-FTS

Number of events:        158
Reactor Critical Years:  55263.8
Component Count:         224
Prior Type:              Jeffreys(a, b)
Prior Source:            Default Jeffreys Update
Prior Parameters:        0.50; 0.50

Posterior Type:          Beta(a, b)
Posterior Parameters:    158.50; 55106.30
Posterior Confidence Interval for 90% Interval:
         5th Percentile:        2.50E-03
                   Mean:        2.87E-03
        95th Percentile:        3.25E-03
Posterior Variance:      5.17E-08
Posterior Std-Dev:       2.27E-04
```

Bayesian Update Industry Result

Refresh

Entries	Dist.	Fail	Demands/Hours	a	b	lower	mean	upper
95	Beta	158	55263.8	1.59E+02	5.51E+04	2.50E-03	2.87E-03	3.25E-03

Shared Rules Result - Empirical Bayes

https://rads.inl.gov/(S(rjsggmu42ed0p3vf50jfycqs))/Pages/Reliability.aspx

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PRA DATA CALCULATIONS WEB SITE
VERSION 1.3.2012.1

NROD Home | RADS Home | Reliability | Availability | Initiating Events | LOOP | CCF | Reliability Calculator | Maintenance | Help

Reliability Rules | Data Analysis Options | Run Batch Reliability Rules

Analysis Type, Grouping, Date Range, and Options
Industry Average Prior
Component Characteristics
Results for rule: EDG-FTS

Refresh

Plant Name	Device Count	Failure Count	Demands
Arkansas 1	2	1	627.74
Arkansas 2	2	1	483.40
Beaver Valley 1	2	0	371.65
Beaver Valley 2	2	1	357.71
Braidwood 1	2	1	504.84
Braidwood 2	2	1	547.59
Browns Ferry 2	4	4	958.15
Browns Ferry 3	4	4	941.76
Brunswick 2	4	3	752.74
Byron 1	2	1	574.83
Byron 2	2	1	604.52
Callaway	2	3	592.76
Calvert Cliffs 1	2	3	489.87
Calvert Cliffs 2	2	2	502.94
Catawba 1	2	0	388.51
Catawba 2	2	0	435.49
Clinton 1	2	1	429.18
Columbia 2	2	1	431.97

Statistical Results for Rule: EDG-FTS | Statistical Information | General Reliability Information

Empirical Bayes Results | Empirical Bayes Charts | Bayes Update Results | Bayes Update Chart

```
Empirical Bayes Analysis for: EDG-FTS

The empirical Bayes method gives a model of the between-item variation that was found by the chi-
squared test.
The Empirical Bayes statistical analyses includes a Kass-Steffey adjustment to the parameters of the
gamma or beta EB population variability distribution.

Number of entries:      95
Component Count:        224
Number of failures:     158
Demands/Run Hours:      55263.8046875
Value of X2 = 124.17, degrees of freedom = 94

p-value = approx. Prob(such a large X2, if rate is the same for all plants) = 2.03E-02

Posterior Type: Beta(a, b)
Posterior Parameters:   7.90; 2710.32
Posterior Confidence Interval for 90% Interval:
        5th Percentile:        1.44E-03
                  Mean:        2.91E-03
```

Empirical Bayes Industry Result

Refresh

Item	Dist.	Fail	Demands/Hours	a	b	lower	mean	upper
95	Beta	158	55263.8	7.90E+00	2.71E+03	1.44E-03	2.91E-03	4.78E-03

Empirical Bayes Individual Results

Refresh

Item	Dist.	Fail	Demands/Hou	a	b	lower	mean	upper
Arkansas 1	Beta	1	627.7	8.72E+00	3.26E+03	1.38E-03	2.67E-03	4.31E-03
Arkansas 2	Beta	1	483.4	8.89E+00	3.18E+03	1.45E-03	2.79E-03	4.48E-03
Beaver Valley :	Beta	0	371.7	7.47E+00	2.90E+03	1.25E-03	2.57E-03	4.29E-03
Beaver Valley :	Beta	1	357.7	8.90E+00	3.07E+03	1.50E-03	2.89E-03	4.65E-03