

Operating Experience Data and Data Analysis

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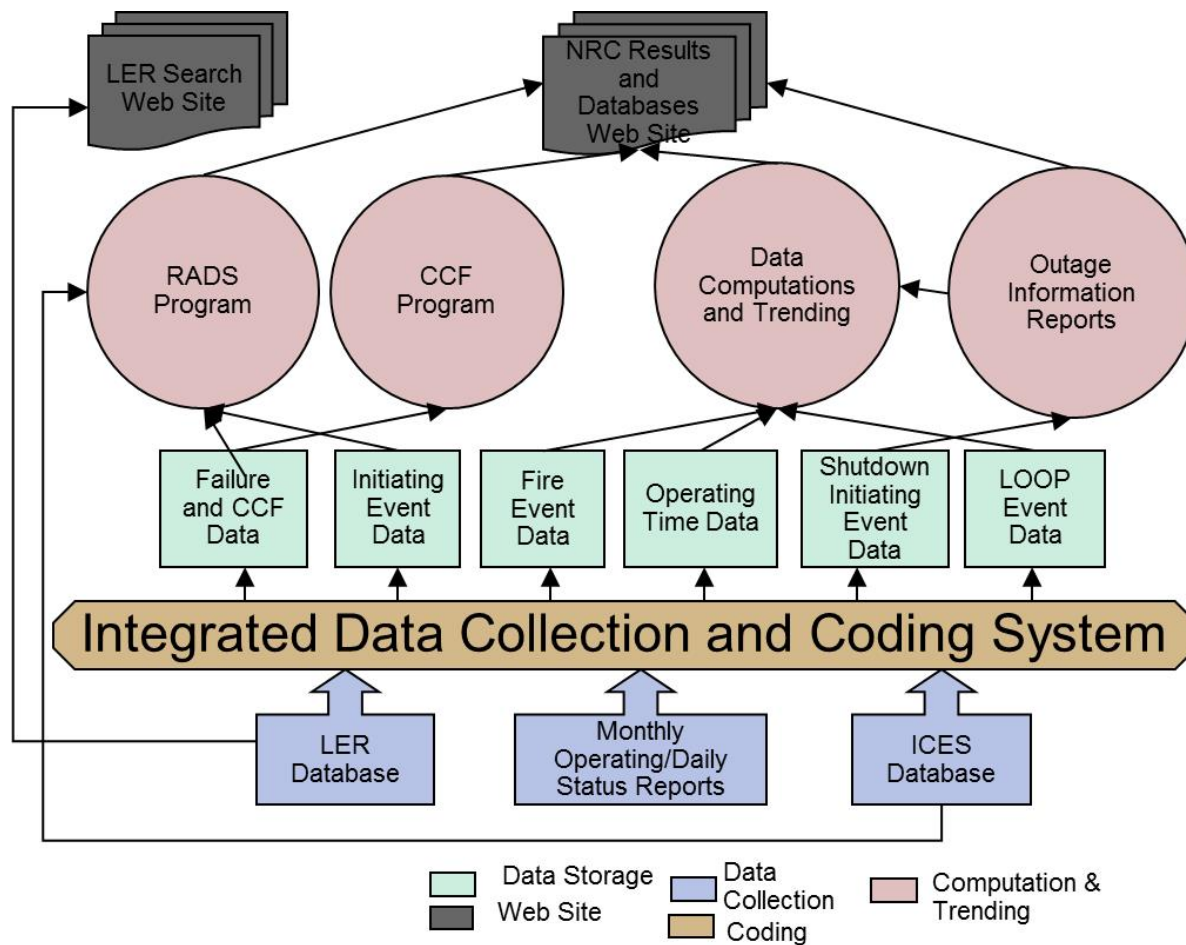
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Introduction

- 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).

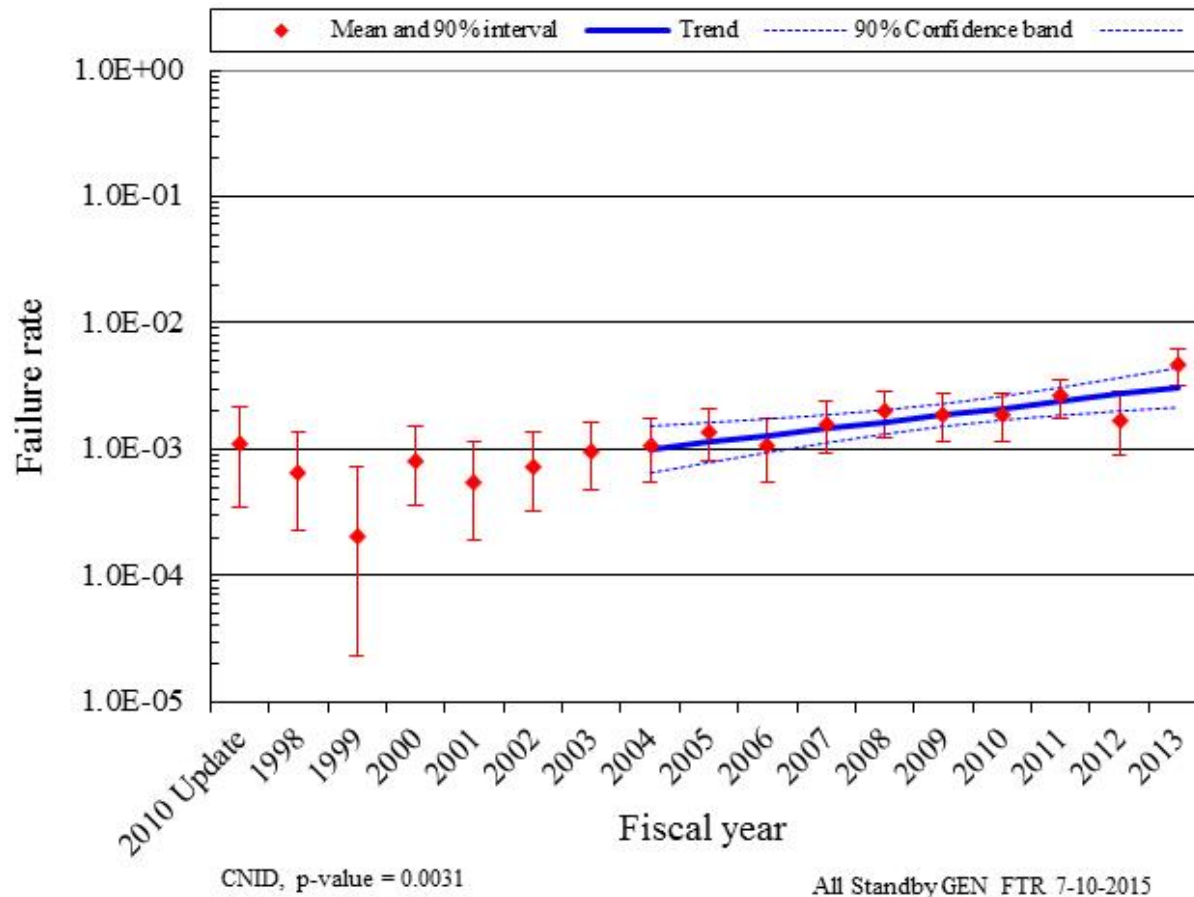
Data Products

- 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

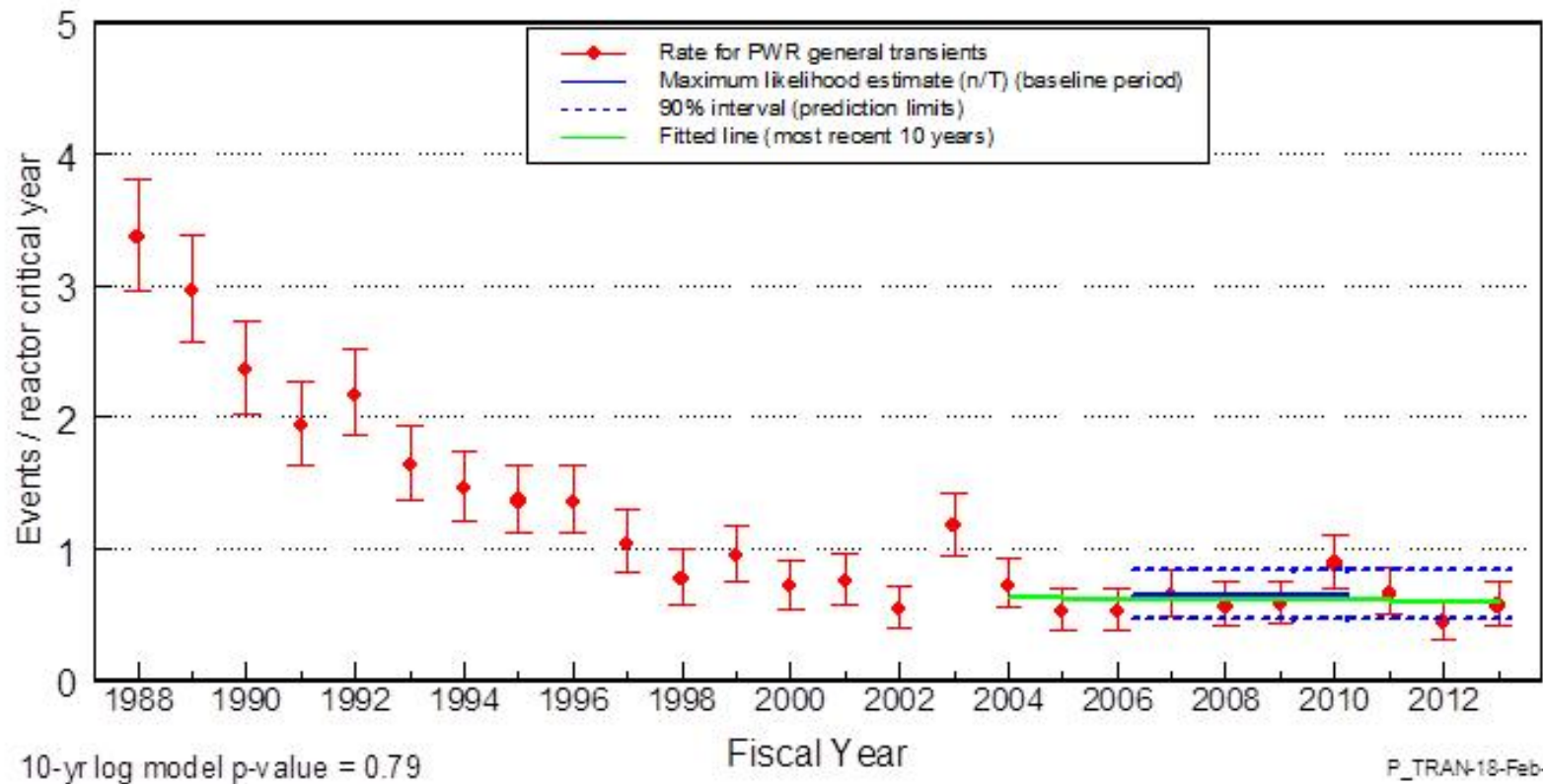
Data Products (cont.)

- 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 | | | | | | | | | |
| 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 |
| | 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 |
| LOIA | 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 |
| | 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 |
| | Loss of Electrical Bus | | | | | | | | | |
| ELECTRICAL POWER | 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 |
| | IE-SD-LOOPWR | Weather Related Contribution to LOOP | IEDB | 16 | 156.5 | Gamma | 1.03E-02 | 8.6 | 11.9 | 2.3 |

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





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NUCLEAR MATERIALS

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PUBLIC MEETINGS & INVOLVEMENT

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- [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](#) [PDF](#)
[Overview and Reference](#) [PDF](#)

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 [PDF](#)

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 your 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

Edit Basic Event - EPS-DGN-FS-DGA

Name: **EPS-DGN-FS-DGA** Probability = 2.891E-03

Description: DIESEL GENERATOR A FAILS TO START

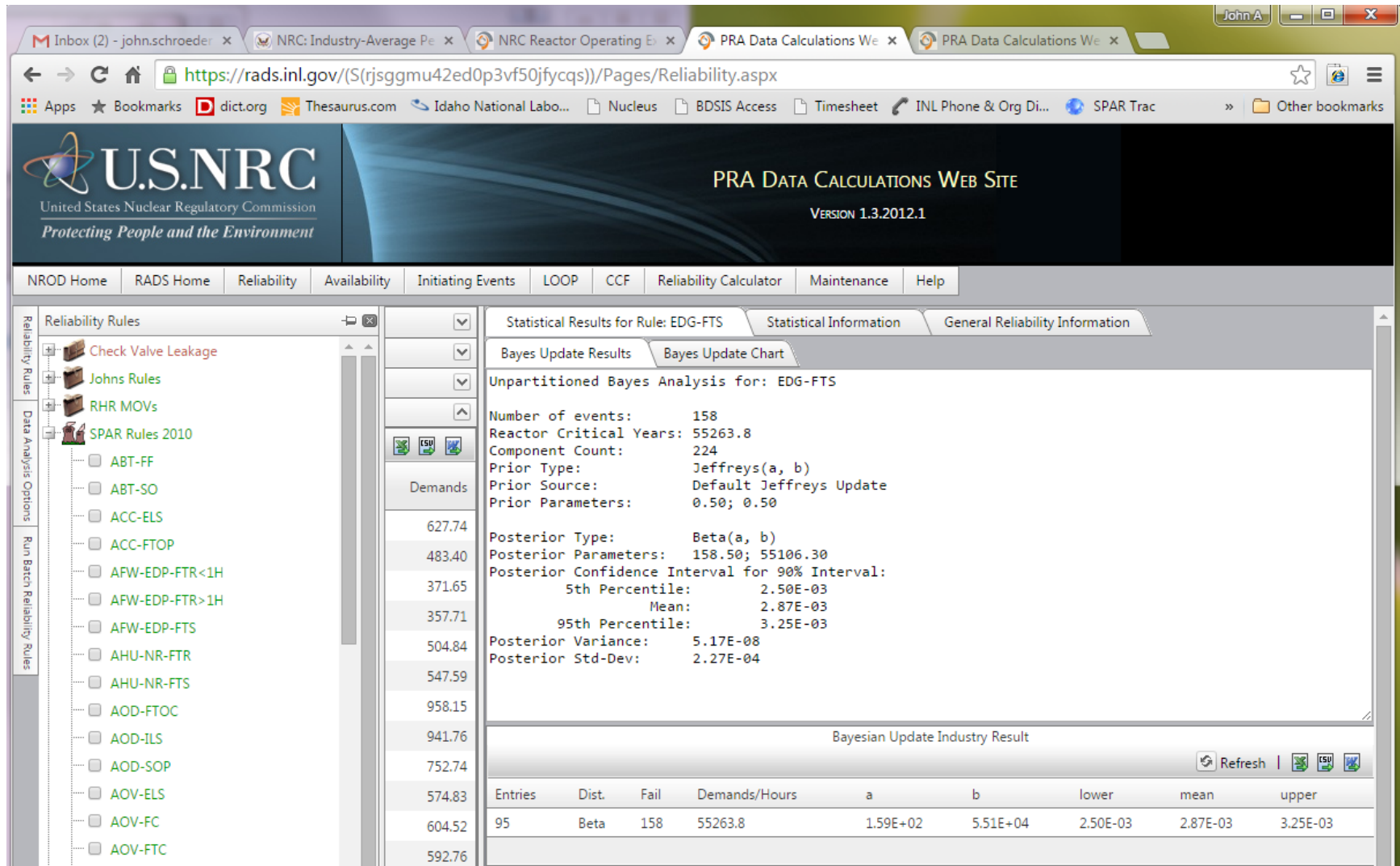
☐ Template Event Default Template: ZT-DGN-FS

Check Boxes indicate using/exporting template properties!

| Failure Model | Attributes | Applicability | Notes | Summary |
|--|------------|---------------|-------|---------|
| <input checked="" type="checkbox"/> Event Notes: 2010 Update to the Parameter Estimation Component Reliability Data Sheets; Section 3.1 Build Date: 07/19/2012 | | | | |
| <input type="checkbox"/> Event Reference: [Empty text box] | | | | |

☐ Save As New

Shared Rules Example



The screenshot shows the PRA Data Calculations Web Site interface. The top navigation bar includes links for NROD Home, RADS Home, Reliability, Availability, Initiating Events, LOOP, CCF, Reliability Calculator, Maintenance, and Help. The main content area displays the 'Reliability Rules' section, which lists various rules such as Check Valve Leakage, Johns Rules, RHR MOVs, and SPAR Rules 2010. The 'Reliability Rules' section is expanded, showing a list of rules with their corresponding demands and failure rates.

The 'Statistical Results for Rule: EDG-FTS' section is also visible, showing the 'Bayes Update Results' and 'Bayes Update Chart' tabs. The 'Unpartitioned Bayes Analysis for: EDG-FTS' section displays the following statistics:

- 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

The 'Bayesian Update Industry Result' section shows a table of results:

| 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

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

PRA DATA CALCULATIONS WEB SITE
VERSION 1.3.2012.1

NRD Home RADS Home Reliability Availability Initiating Events LOOP CCF Reliability Calculator Maintenance Help

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

Statistical Results for Rule: EDG-FTS
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

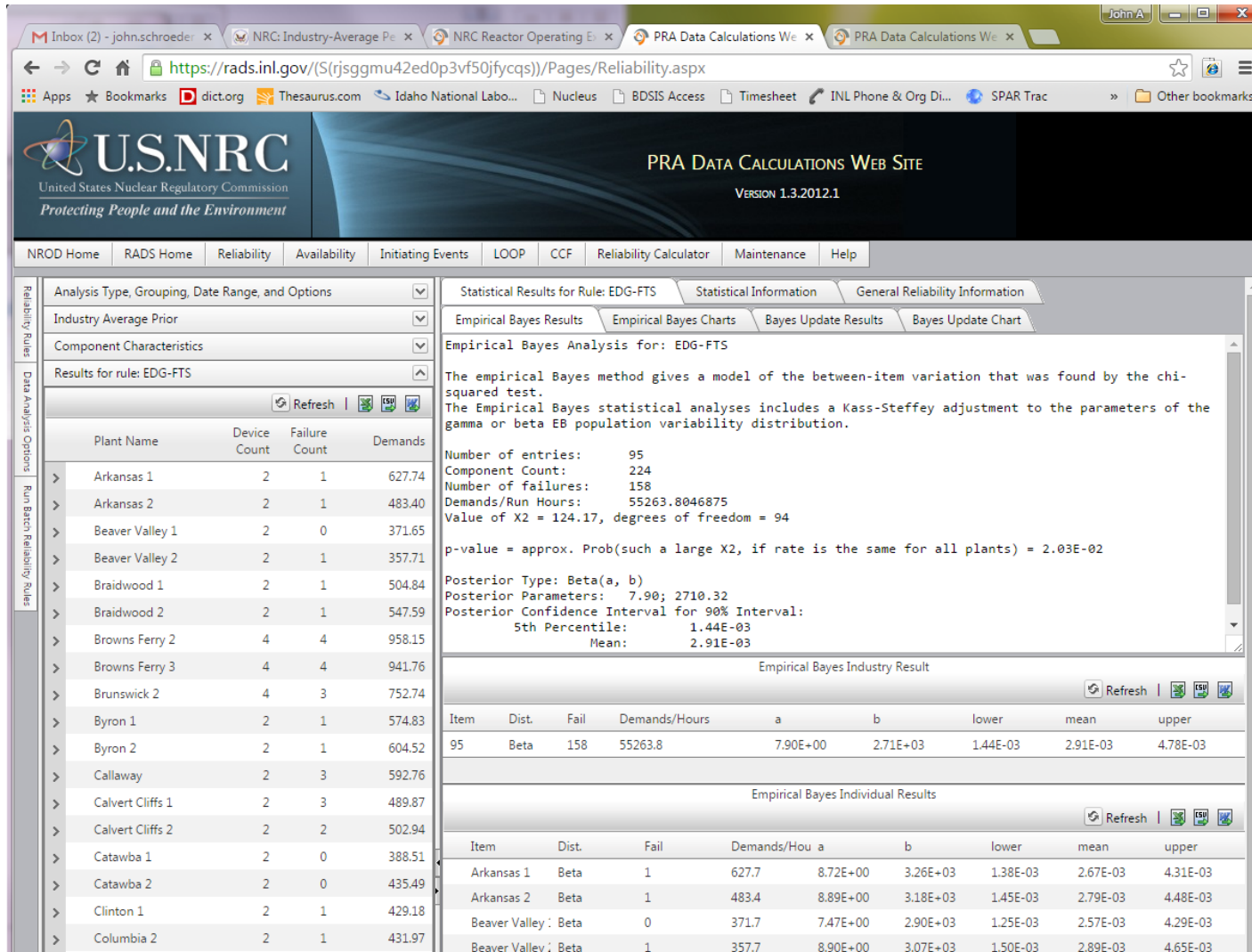
Posterior Type: Beta(a, b)
Posterior Parameters: 158.50; 55106.30
Posterior Confidence Interval for 90% Interval:
5th Percentile: 2.50E-03
Mean: 2.87E-03
95th Percentile: 3.25E-03
Posterior Variance: 5.17E-08
Posterior Std-Dev: 2.27E-04

Bayesian Update Industry Result

| 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 |

| 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



The screenshot shows the PRA Data Calculations Web Site (VERSION 1.3.2012.1) with the following components:

- Navigation Bar:** NROD Home, RADS Home, Reliability, Availability, Initiating Events, LOOP, CCF, Reliability Calculator, Maintenance, Help.
- Left Sidebar:**
 - Reliability Rules: Analysis Type, Grouping, Date Range, and Options; Industry Average Prior; Component Characteristics.
 - Data Analysis Options: Results for rule: EDG-FTS.
 - Run Batch Reliability Rules.
- Main Content Area:**
 - Statistical Results for Rule: EDG-FTS** (Selected Tab):
 - Empirical Bayes Results:**

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:**

| 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:**

| 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 | Beta | 0 | 371.7 | 7.47E+00 | 2.90E+03 | 1.25E-03 | 2.57E-03 | 4.29E-03 |
| Beaver Valley : Beta | Beta | 1 | 357.7 | 8.90E+00 | 3.07E+03 | 1.50E-03 | 2.89E-03 | 4.65E-03 |