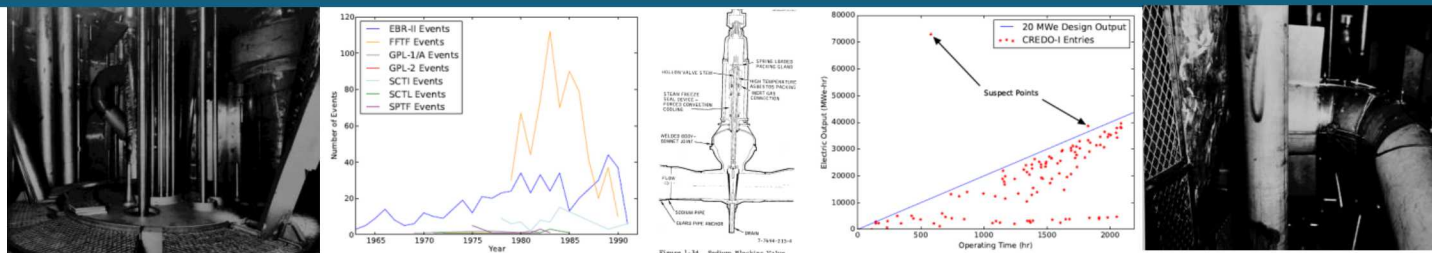
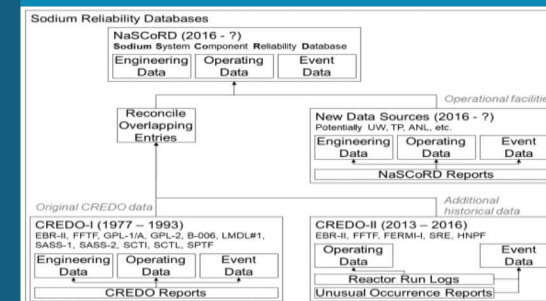




Sodium Pump Performance in the NaSCoRD Database



PRESENTED BY

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Knowledge Management and Preservation

- US operational data from sodium reactors and test loops was feared lost after ORNL lost control of the data in the mid-1990s.
- In 2016, JAEA transferred the “flat” version of the US portion of the Centralized Reliability Data Organization (CREDO) database.

Future test complex insights

- CREDO contains failure data and operational records from the FFTF and EBR-II reactors and the WARD and ETEC loops.
- New reactors and loops will likely use similar physical components to those used in the historical facilities and can learn from their experiences.

Probabilistic Risk Assessment (PRA) support

- CREDO data was used to support MONJU, PRISM, and EBR-II PRAs.
- This data can be a valuable resource to future SFR PRAs.

Overview of the NaSCoRD Database

- Database Overview
- Types of Components
- Data Quality Efforts

Focus on Sodium Pump Insights

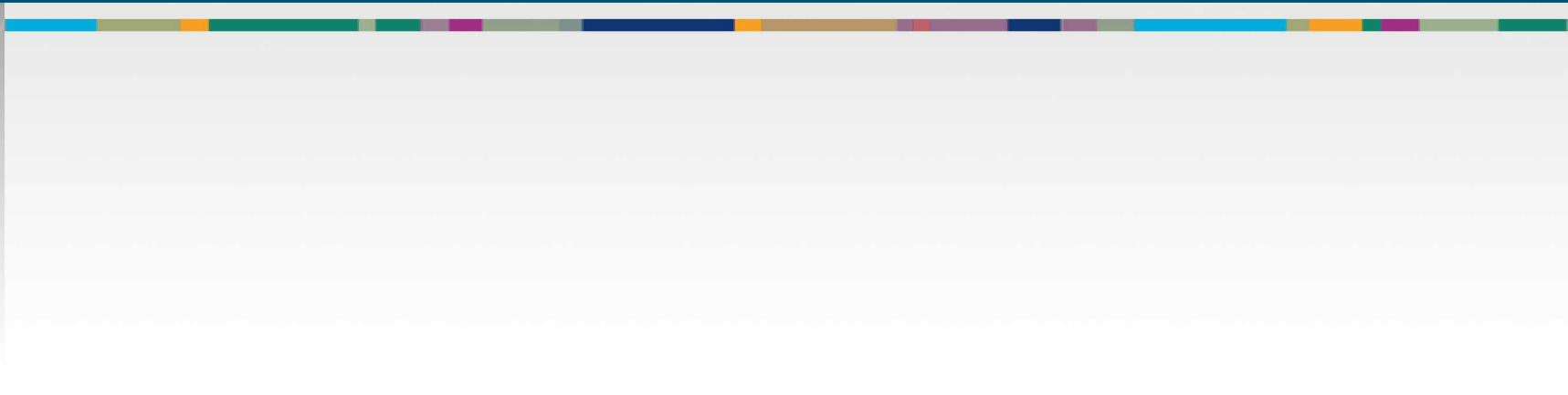
- Data Processing Method
- Prior Distribution
- Posterior Distribution

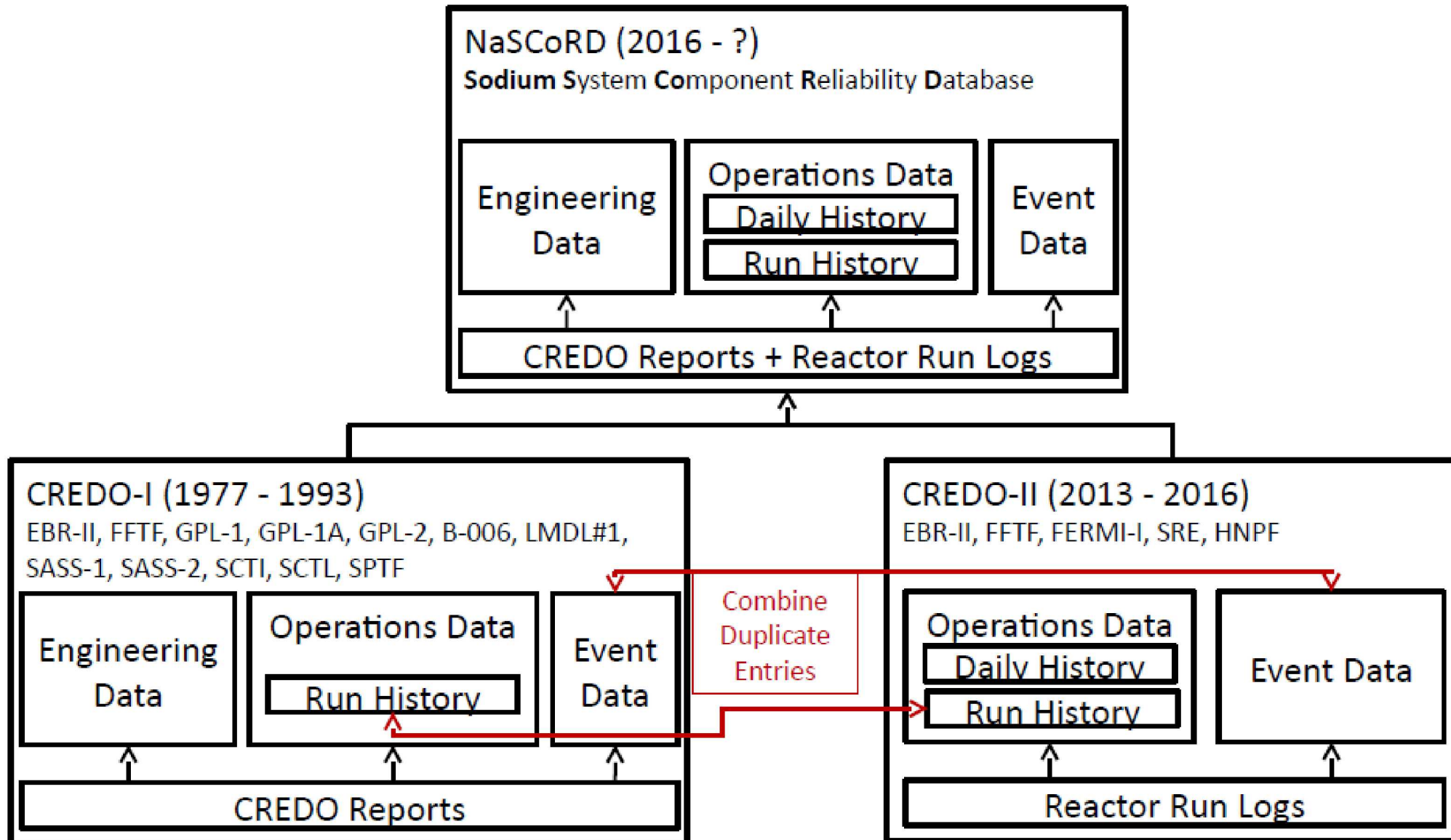
Path Forward

- Conclusions
- Requesting Access

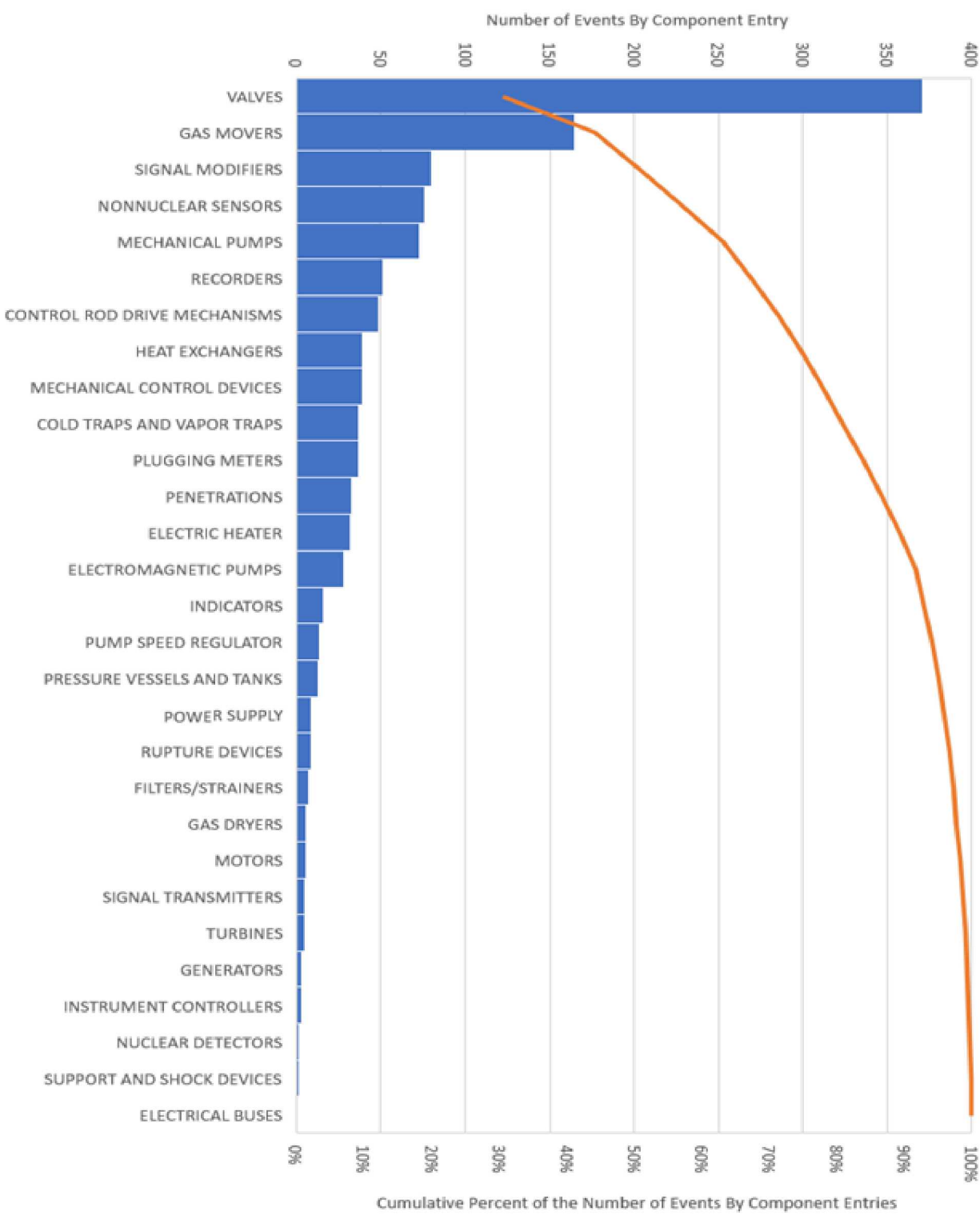


Overview of the NaSCoRD Database

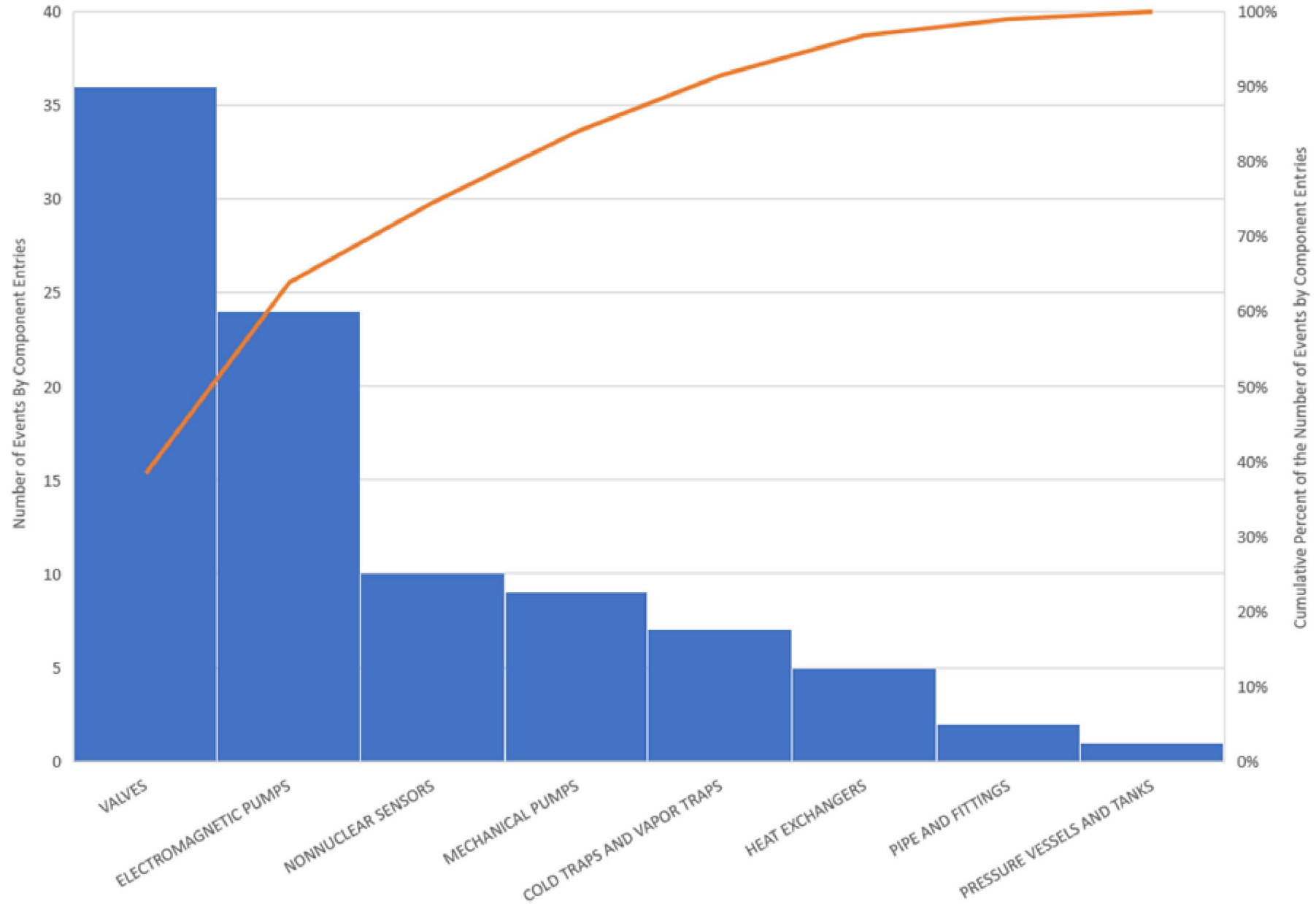




NaSCoRD Reactor Events by Component



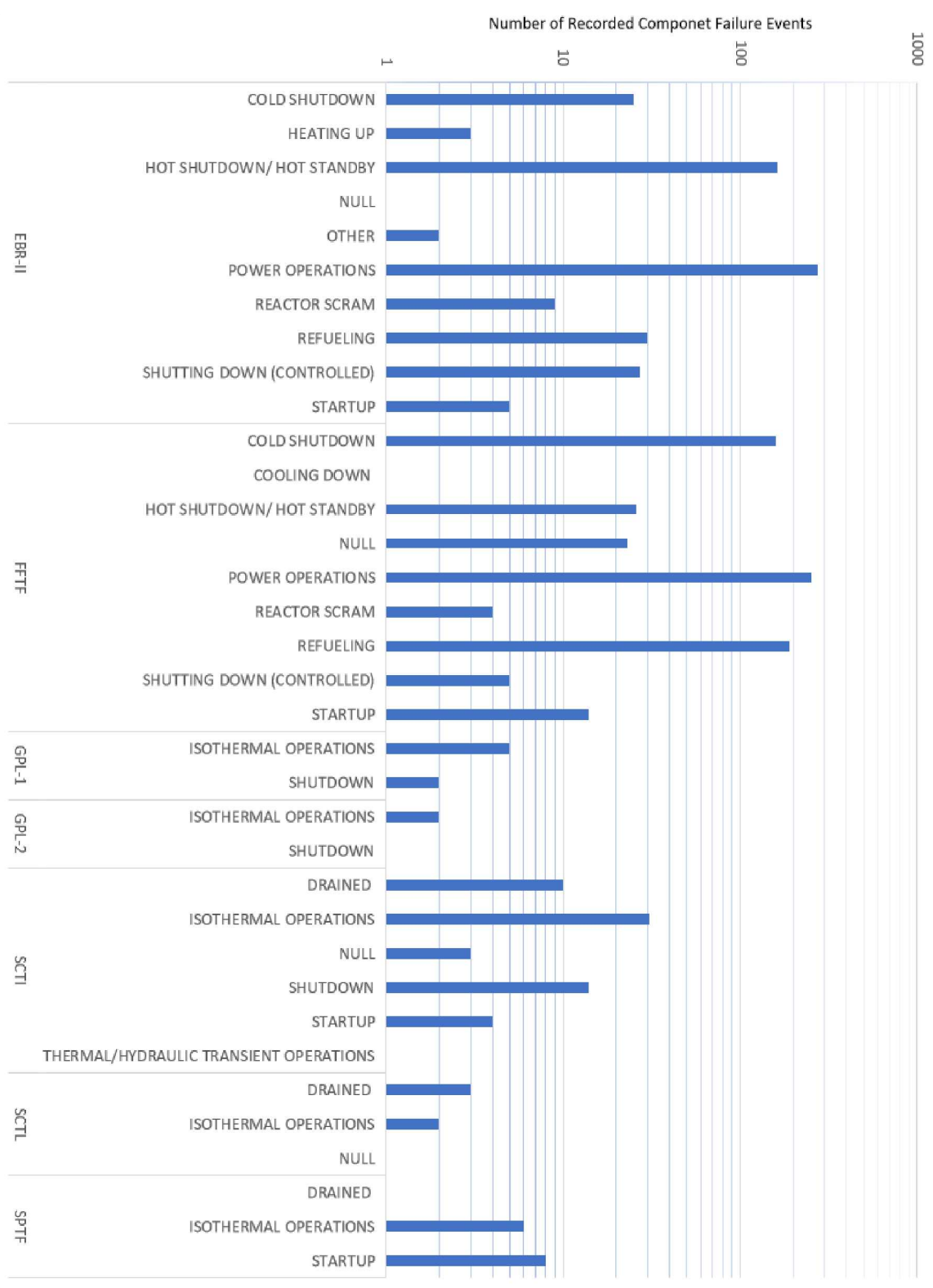
NaSCoRD Test Loop Events by Component



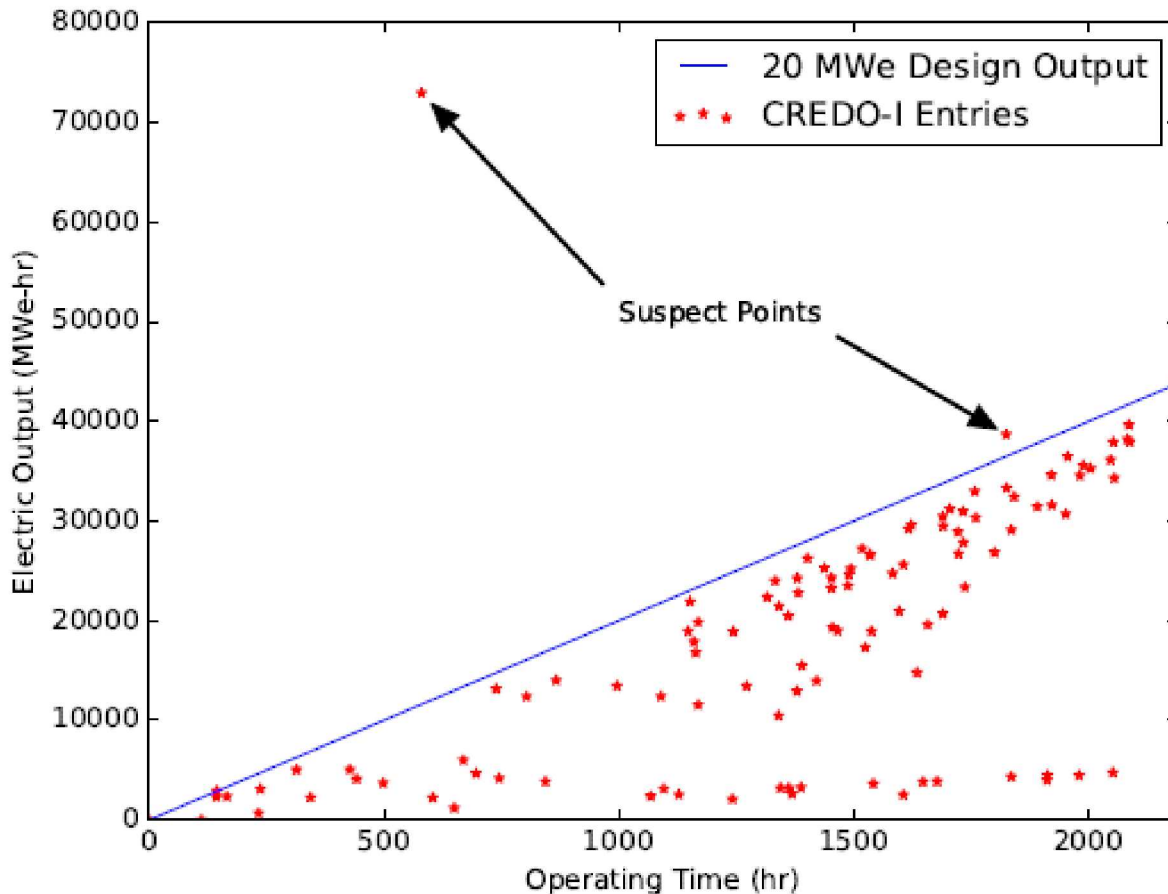
NaSCoRD Provides a Rich and Multifaceted Database

The NaSCoRD database records:

- State of the system or facility (operational, standby, maintenance, ...) →
- Component Descriptions, Operating Conditions, Design Levels
- Human interactions with components
- Links to additional records (if still available)



Some Data Quality Questions Remain



EBR-II

Original data collection efforts occurred in the early days of PRA

- Failure boundaries were not always well defined
- Data was passed back and forth from ORNL and JAEA
- Data quality questions remain but should be resolvable when NaSCoRD is combined with other data sources

Searchability

- Input format was often inconsistent between reporters even at the same facility
 - Leads to difficulty in searching the data
 - Resolved when inspecting data for other purposes



Focus on Sodium Pump Insights



Prior

$$EG\&G\ Idaho: p(\lambda|\sigma^2, \mu) = \frac{1}{\lambda\sqrt{2\pi\sigma^2}} \exp\left(\frac{-(\ln \lambda - \mu)^2}{2\sigma^2}\right) \text{ for } \lambda > 0$$

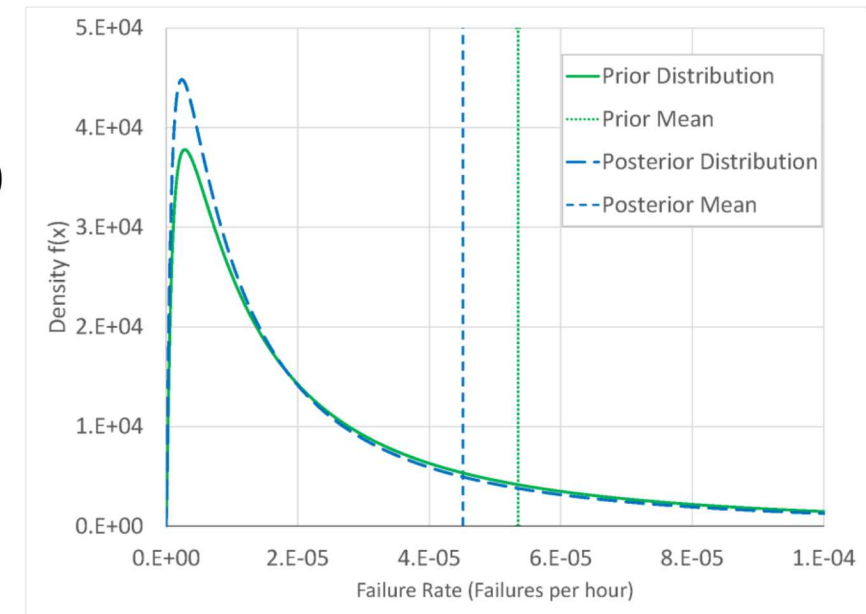
$$Noninformative : p(\lambda|\alpha = 0, \beta = 0) = \frac{\beta^\alpha \lambda^{\alpha-1} e^{-\beta\lambda}}{\Gamma(\alpha)} = \lambda^{-1} \text{ for } \lambda > 0$$

Likelihood – NaSCoRD Data

$$f(\underline{y} | \lambda) = \prod_{i=1}^n \left(\frac{1}{\lambda} \exp\left(-\frac{y_i}{\lambda}\right)\right) \prod_{j=1}^m \left(\exp\left(-\frac{y_j}{\lambda}\right)\right) \text{ for } \lambda, y_i, y_j > 0$$

Posterior – Calculated via Bayesian Updating

$$p(\lambda | \underline{y}) \propto f(\underline{y} | \lambda) p(\lambda)$$

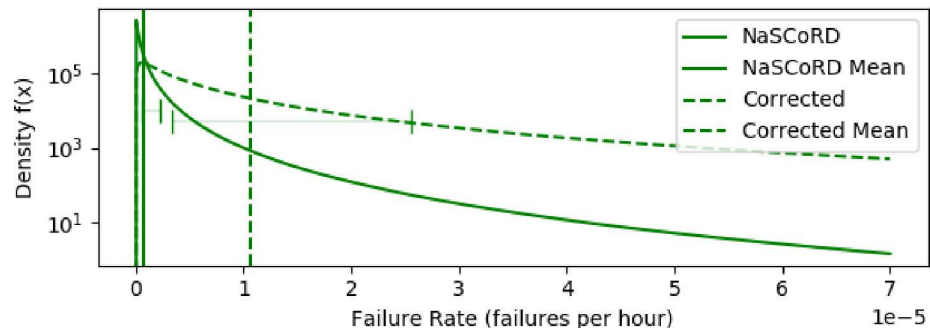
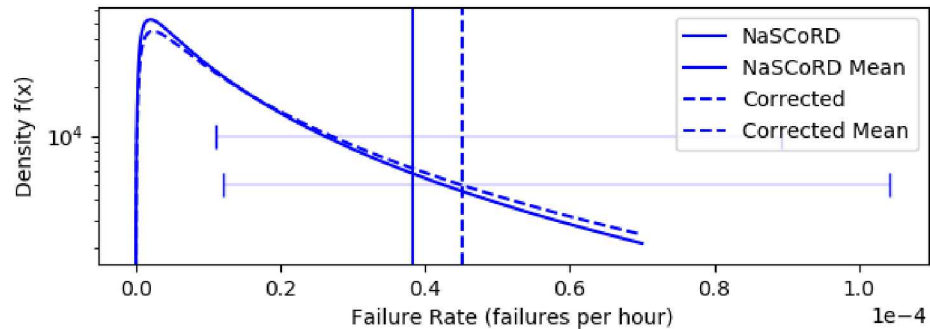
**Mechanical Pump,
Total Failure Rate**

Impact of EG&G Idaho Revised Failure Modes on Posterior



SNL has updated NaSCoRD's reported failure modes based upon EG&G Idaho's recommendations.

- Did these changes significantly impact the final results?
- Was there enough evidence to overwhelm the EG&G Idaho recommendations?



Mechanical Pump,
Total Failure Rate

Electromagnetic Pump,
Total Failure Rate

Table A-9. Review of motor-driven pump CREDO failures

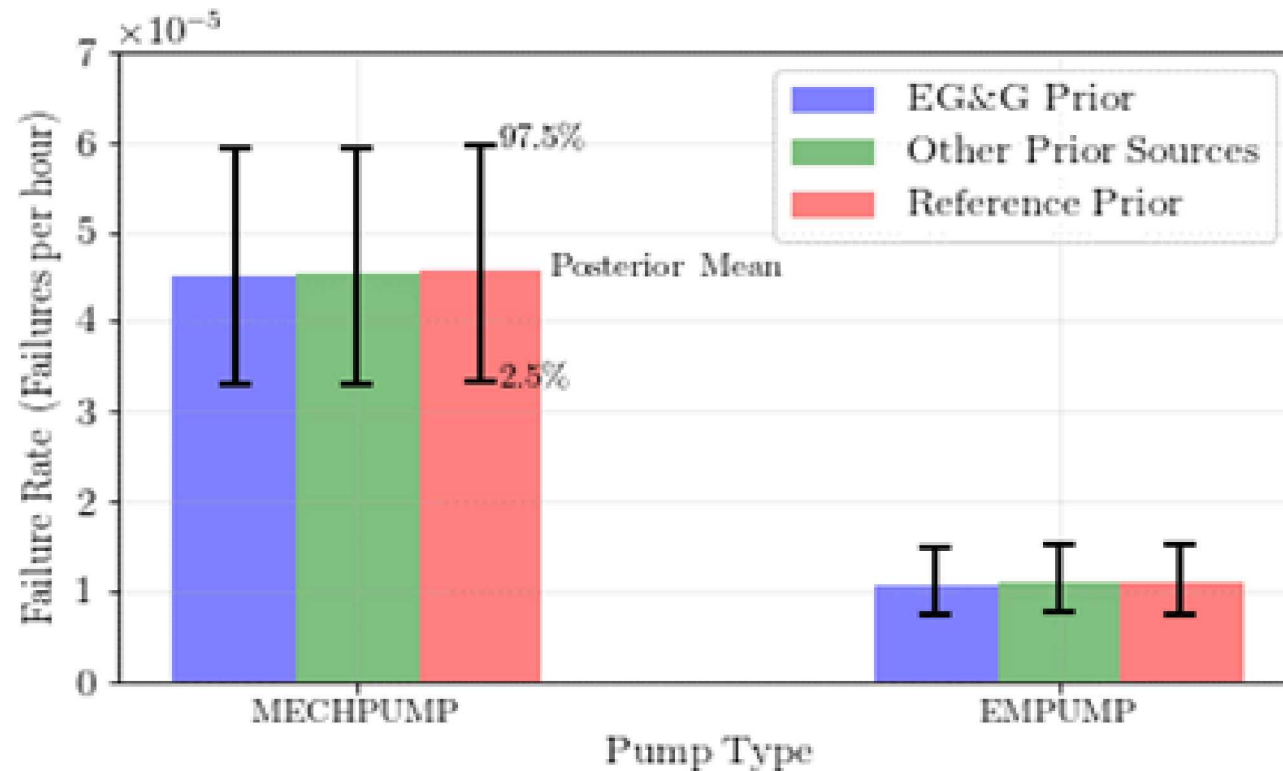
| <u>No.</u> | <u>Event</u> | <u>Failure Mode</u> | <u>Revised Failure Mode</u> | <u>Include?</u> |
|------------|--------------|---------------------|-----------------------------|-----------------|
| 1. | JY860016 | SPURIOUS | | YES |
| 2. | ER860014 | ABNORMOP | | YES |
| 3. | ER650001 | SEIZED | NOSTART | YES |
| 4. | ER630002 | SPURIOUS | | YES |
| 5. | ER650002 | SEIZED | NOSTART | YES |
| 6. | ER700003 | ABNORMOP | | YES |
| 7. | ER700004 | ABNORMOP | | NO |
| 8. | ER730001 | ABNORMOP | | YES |
| 9. | ER770003 | ABNORMOP | | NO |
| 10. | ER800005 | SPURIOUS | | YES |

Impact of Prior Assumptions on Posterior



Significant overlap of 95% uncertainty bands for posterior means for all priors

- Evidence is sufficient to outweigh prior



Some significant shifts from prior



| Pump | Failure Mode | EG&G Prior Mean | Evidence (Hours, Failures) | Posterior Mean | 95% Probability Interval |
|-----------------|------------------|-----------------|----------------------------|----------------|--------------------------|
| Mechanical | Failure to Run | 5.0E-5 | (1.0E6, 26) | 2.6E-5 | (1.7E-5, 3.6E-5) |
| | External Leakage | 3.0E-6 | (1.0E6, 15) | 1.4E-5 | (1.3E-5, 1.6E-5) |
| | Total | 5.4E-5 | (1.0E6, 46) | 4.5E-5 | (3.3E-5, 6.0E-5) |
| Electromagnetic | Failure to Run | 1.0E-5 | (2.9E6, 27) | 9.1E-6 | (6.0E-6, 1.3E-5) |
| | External Leakage | 3.0E-6 | (2.9E6, 1) | 5.1E-7 | (8.1E-8, 1.6E-6) |
| | Total | 1.3E-5 | (2.9E6, 32) | 1.1E-5 | (7.3E-6, 1.5E-5) |

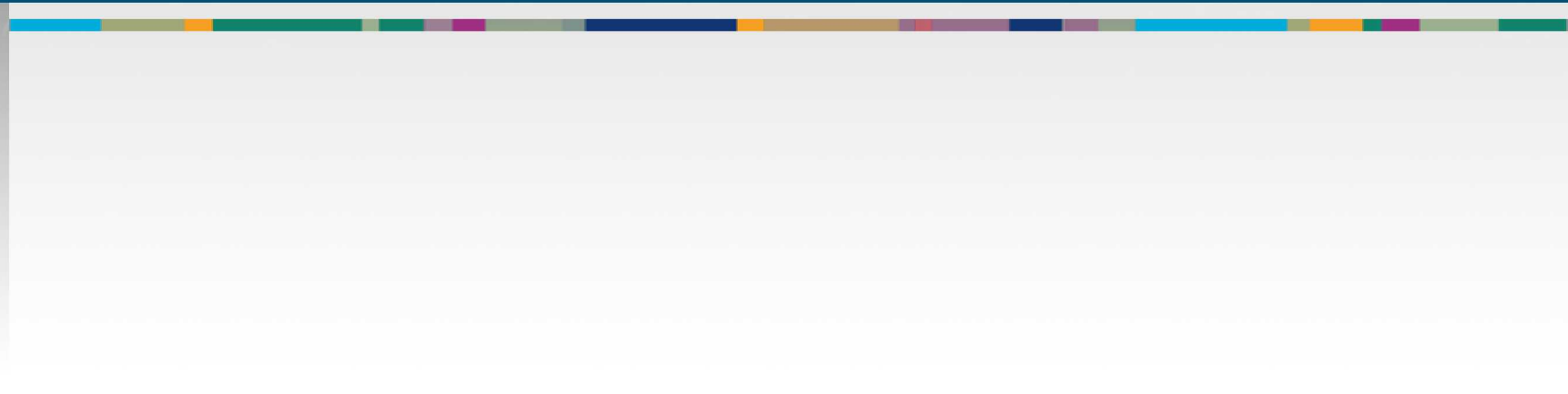
Total failure rates changed little

More mobility in external leakage failure rates

- NaSCoRD covers four more years of CREDO reports than the 1990 EG&G Idaho report
- NaSCoRD does not include the Joyo reactor or Japanese test facilities
 - Sixteen Joyo EM pump failures reported to CREDO by the time of the EG&G Idaho report



Wrapping Up



Posterior failure rates for sodium fast reactor pumps produced in this analysis were mostly consistent with failure rates produced from the CREDO data prior to 1990.

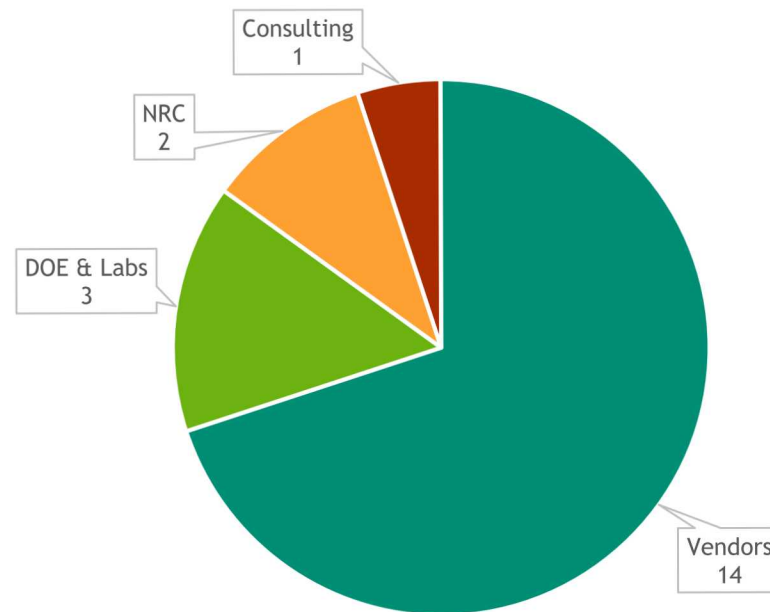
- Many factors were tested that could have potentially changed inferences regarding the pump failure rates such as prior assumptions and cleaning recommendations from SNL and EG&G Idaho.
- Most of the NaSCoRD data is robust to EG&G Idaho data cleaning recommendations.
- The information lost due to the absence of the JAEA data may have changed the conclusions regarding external leakage failure rates.

Current External NaSCoRD Users



The usual suspects

- Established and startup reactor vendors
- Including support for the versatile test reactor program



Requesting Access to the NaSCoRD Database



NaSCoRD is access controlled

- To request access, go to www.sandia.gov/nascord
- SNL approval (according to DOE and SNL standards) are required before access is granted.
 - Export Controlled Information
- NaSCoRD access is provided to external users via Microsoft SQL HTML reports.



Yesterday Informing Tomorrow

Introduction

This database was developed as part of a United States DOE Nuclear Energy Advanced Reactor Technologies program. The project's mission is to re-create the capabilities of the legacy Centralized Reliability Database Organization (CREDO) database. The CREDO database provided a record of component design and performance documentation across various systems that used sodium as a working fluid but was lost by its US custodian in the 1990s. Raw data of US origin was only recently recovered from the Japan Atomic Energy Agency (JAEA) with whom the US had established a joint database. This NaSCoRD database uses reconstructed CREDO data (CREDO-I) with reliability information sourced from operational documents, unusual occurrence reports, and design documents, called CREDO-II.

Capabilities

CREDO-I, CREDO-II, and Sodium System Component Reliability Database (NaSCoRD) will immediately benefit sodium system designers who can extract engineering, operational, and safety insights from these data sets. The ability to examine the failure modes for sodium components and the environments that led to multiple and repeated component failures will allow for future sodium loop and sodium reactor designers to leverage the expansive legacy of domestic sodium reactor operations. The future expansion of NaSCoRD to new facility data sources provides the domestic industry with the best opportunity to develop a broad database to support future Probabilistic Risk Assessment (PRA) applications.

Contact

NaSCoRD
NaSCoRD@sandia.gov

Database Access

To allow the domestic sodium industry access to this data, Sandia has established a controlled access website for users to directly explore SQL reports. Access to NaSCoRD can currently be requested through the DOE-NE ART sodium reactor program manager. Request access by e-mailing NaSCoRD@sandia.gov.

Resources



[NaSCoRD SAND Report](#)
 Creation of the NaSCoRD Database.
 (3.97 MB PDF)