NRC Reactor Operating Experience Data

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Abstract: Idaho National Laboratory (INL) has been providing technical assistance to the U.S. Nuclear Regulatory Commission Division of Risk Analysis in the Office of Nuclear Regulatory Research in the areas of data collection and reliability and risk calculation. INL collects, codes, assures the quality of, and maintains all reactor operating experience data necessary to support the Industry Trends Program and various risk-associated NRC studies requiring reactor operating experience data. The types of data collected under this effort include initiating event data, system reliability data, loss of offsite power data, common cause failure data, fire event data, and shutdown initiating event data. The data sources for this effort primarily consists of Licensee Event Reports (LERS), Event Notifications, and equipment failure reports provided by the Institute for Nuclear Power Operations (INPO). This data is analyzed and results published annually on the NRC website. The data is primarily used to support the NRC's standardized plant analysis risk (SPAR) models but also provides generic industry average values for use by the industry in their individual PSA models. This paper characterizes the types of data collected, the various uses of this data, and the methods of collection, storage and retrieval.

Keywords: Data, Operating Experience.

1. INTRODUCTION

Idaho National Laboratory (INL) provides technical assistance to the US Nuclear Regulatory Commission Division of Risk Analysis in the Office of Nuclear Regulatory Research in the areas of data collection and reliability and risk calculation. The results of this work are generally made publically available on the NRC's website to support various PSA activities. In addition, several specialized databases and data tools are provided to the public. INL also supports the NRC's Industry Trends Program (ITP) in the areas of operating experience data and models. INL maintains a database of operating experience data to support various ongoing studies related to Probabilistic Safety Analysis (PSA) including initiating events, system reliability, loss of offsite power, and common cause failure studies. The primary sources of NRC operating experience data are Licensee Event Reports (LERS), Event Notifications and equipment reliability data collected by the Institute for Nuclear Power Operations (INPO). This paper outlines the NRC's Reactor Operating Experience Data Collection and Analysis Program, including data collection, data sources and some of the uses of this operating experience data.

2. DATA COLLECTION METHODS

The Integrated Data Collection and Coding System (IDCCS) provides the structure to ensure consistent data collection, coding, and quality assurance of reactor operating experience data. IDCCS is a program using a Microsoft™ Access project (.adp) user interface to a SQL Server database (SQL Server 2008 R2). Each record in IDCCS is linked to a source document such as an LER or INPO failure record. Source documents are organized by "events". An event is defined by a plant and date; therefore, while viewing an event, all documents and records for a given plant on a given day are displayed. The use of the event concept helps to prevent creating duplicate records from multiple data sources. The process to collect operating experience data includes several quality controls to maintain data integrity including:

- 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.

Figures 1 and 2 outline the data collection, coding and analysis process including quality assurance activities.

Figure 1: INL Data Collection and Coding Process

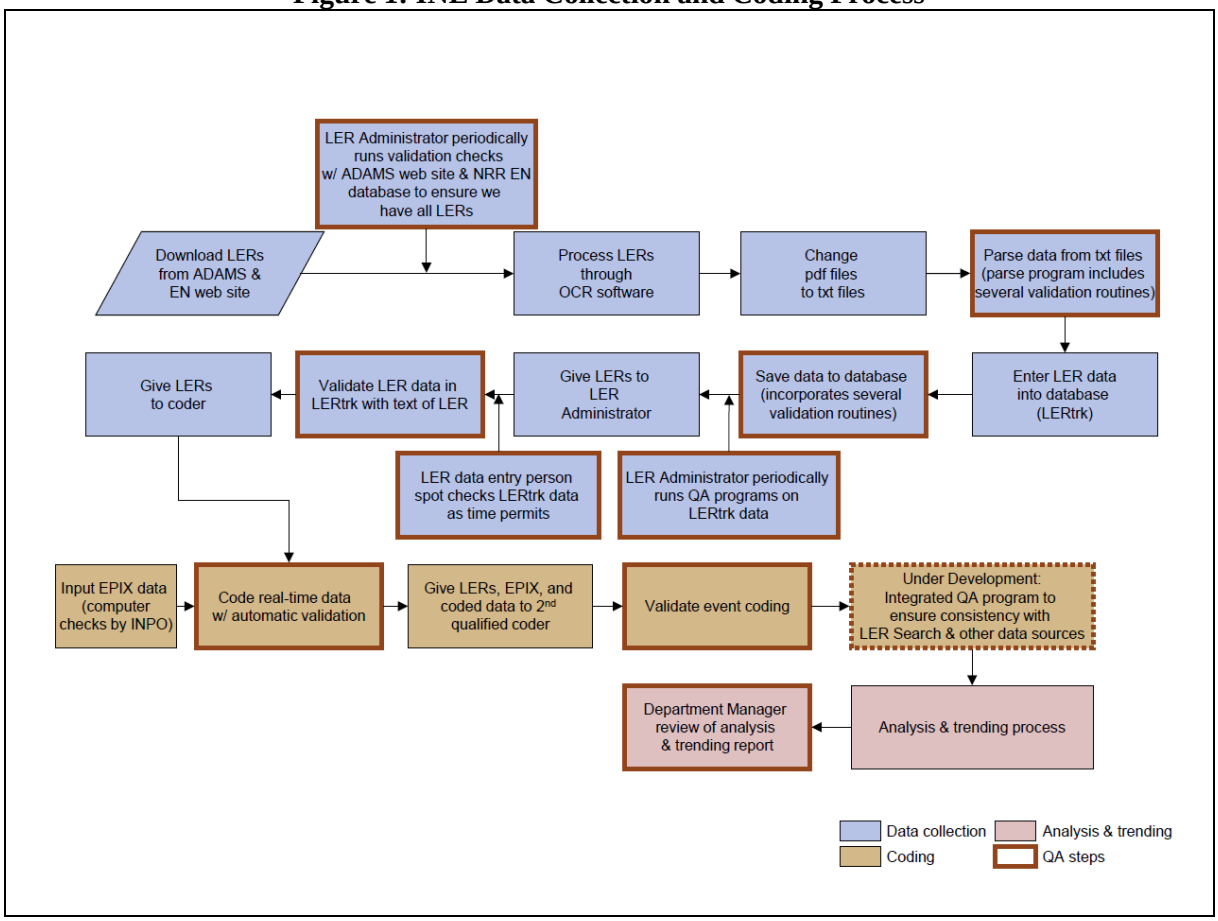
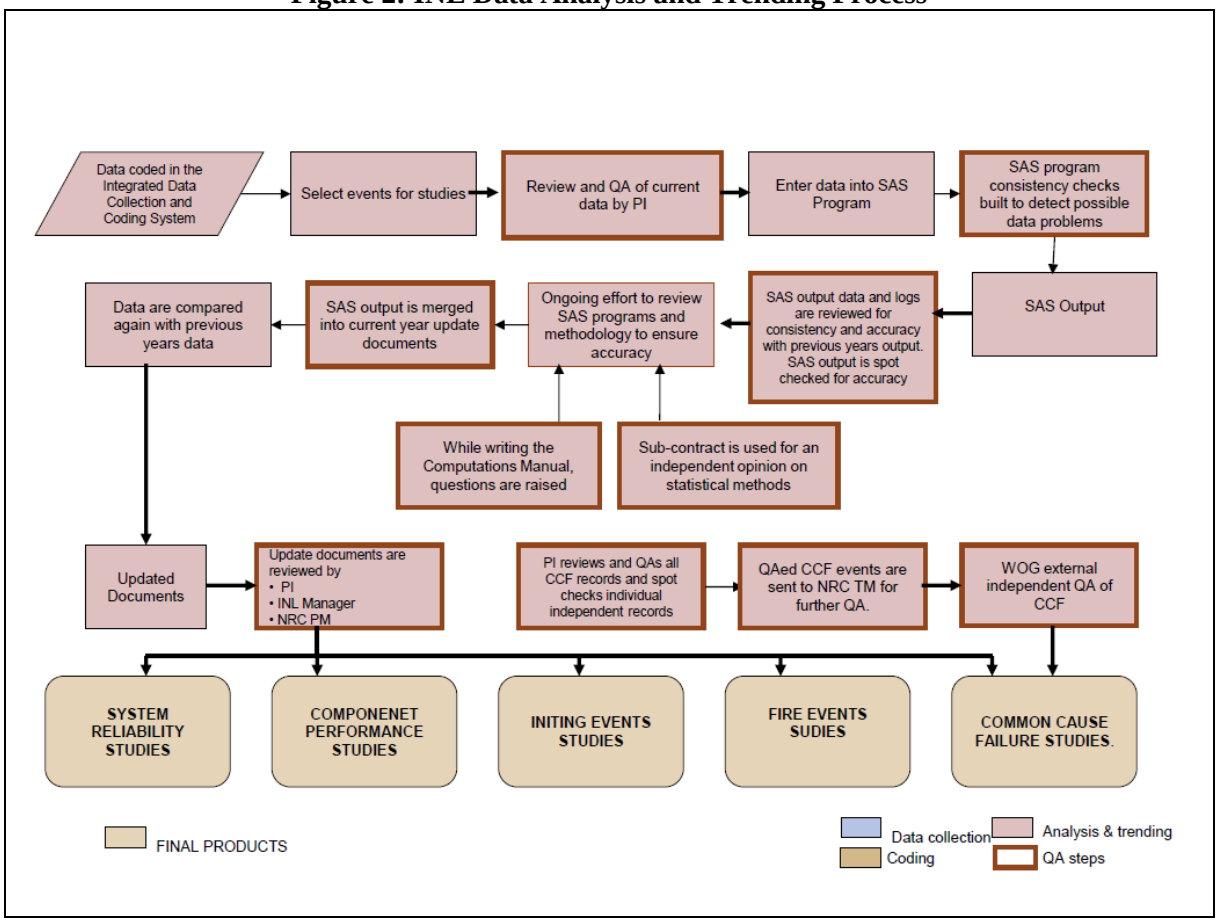


Figure 2: INL Data Analysis and Trending Process

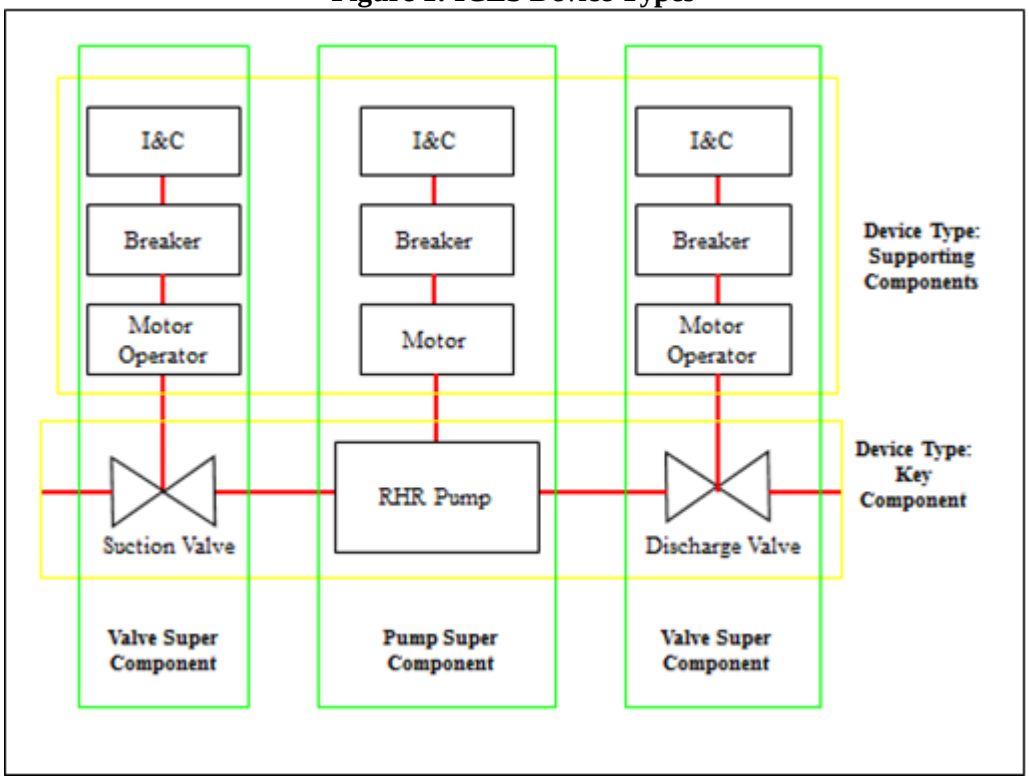


3. PRIMARY NRC REACTOR OPERATING EXPERIENCE DATA SOURCES

3.1. Equipment Reliability Data

The primary source of equipment reliability data is from the Institute of Nuclear Power Operations (INPO). All US nuclear power plants report equipment reliability data via INPOs Consolidated Event System (ICES), formerly the Equipment Performance and Information Exchange (EPIX) System Database. ICES is part of a larger INPO data collection program, Consolidated Date Entry (CDE). ICES supports several regulatory functions, including support for the maintenance rule and the Mitigating Systems Performance Index (MSPI). ICES data are provided to INL quarterly through a contract between INPO and the NRC. INL is allowed to publish industry average equipment performance information, but does not publish individually identifiable failure reports to the public. ICES data supports the industry average parameter estimates, systems studies, component performance studies, and common-cause failure studies. Individual components are referred to as devices in the ICES database. Devices can be Key Components, Sub-Components, or Supporting Components. Figure 3 shows the relationship between the device types.

Figure 1: ICES Device Types



The ICES database contains over one million devices, of which approximately 140,000 are Key Components. INL only codes failure records for select set of devices in the ICES database, queries in IDCCS capture failure records for those devices of interest. Additionally, since the data entered into the ICES database is not specifically for PSA purposes, INL staff code the failure records of interest into the IDCCS database to ensure consistent capture of failure modes and related information.

INL provides a software tool to allow analysts to estimate industry and plant-specific reliability and availability parameters for selected components in risk-important systems for PSA applications. This tool is known as the Reliability and Availability Data System (RADS). RADS contains data and information based on INPOs ICES database. RADS uses failure data from 1997 through present and initiating events from 1987 through present. Since ICES data are proprietary, the NRC only provides the RADS database and the RADS analysis software to nuclear power plant licensees who are members of INPO and NRC staff on request. The reliability parameters estimated by RADS include:

- Probability of failure on demand
- Failure rate during operation
- Maintenance out-of-service unavailability
- Initiating event frequencies
- Time trends in reliability parameters.

INPO members or NRC staff may request access to RADS from a link at http://nrcoe.inl.gov/resultsdb/RADS/. A publically available reliability calculator is available at the same web link. The public calculator is not linked to ICES data.

3.2. Licensee Event Reports

Licensee Event Reports (LERs) are the only source for initiating event data and are the primary source of data for the Loss of Offsite Power study. LERs are downloaded from the NRC's Agency-wide

Documents Access and Management System (ADAMS) weekly. LERs are required by NRC regulation under Title 10 of the Code of Federal Regulations (10 CFR) Part 50.73. Additional guidelines for LER reporting is provided in NUREG 1022, rev. 3. In addition to collecting LERs for coding into the IDCCS, INL maintains a public, searchable database of LERS for the NRC at https://lersearch.inl.gov/LERSearchCriteria.aspx. LER Search contains LERs from 1980 to present.

3.3. Operating Time Data

Operating time data, including reactor critical years, shutdown time and total reactor years are required for a variety of risk analysis studies being conducted by the NRC. The primary sources of operating time data are the Monthly Operating Reports (MORs). MORs are required per NRC Generic Letter 97-02, and are submitted to INPO monthly by each licensee. Quarterly the MOR data is provided to the NRC and then to INL. INL maintains a database of MOR data called MORTRK. Additional outage information is maintained in a database maintained by INL called OUTINFO. Each morning the NRC Operations Center contacts each commercial nuclear power plant and obtains a verbal operations status report. This information is reviewed and a record of each plant outage is created in OUTINFO. These two data sources provide a complete picture of commercial nuclear power plant operating time.

4. PRIMARY USES OF NRC REACTOR OPERATING EXPERIENCE DATA

4.1. Industry Average Probabilistic Risk Assessment (PRA) Parameter Estimates

The NRC maintains risk models covering all U.S. commercial nuclear power plants. These standardized plant analysis risk (SPAR) models support NRC staff in regulatory decision-making, evaluation of inspection findings, and precursor studies. The SPAR models utilize industry average data for initiating event frequencies and component failure rates. The NRC published the results and parameter estimation process to estimate component failure probabilities, component failure rates, maintenance unavailability, and initiating event frequencies in NUREG/CR-6928 [1]. The data used to characterize industry-average performance in NUREG/CR-6928 was typically from the years 1998-2002. Rather than periodically publishing revisions to NUREG/CR-6926, updated parameter estimates are now posted on the NRC's website at http://nrcoe.inl.gov/resultsdb/. The most recent parameter estimates available on the website include industry average performance data collected through 2010.

4.2. Common-Cause Failure Parameter Estimates

INL maintains a database of common-cause failure (CCF) data for the NRC. CCF data collection for the NRC consists of CCF event identification, coding, and parameter estimation. CCF failure events satisfy four criteria:

- Two or more individual components fail, are degraded (including failures during demand or in-service testing), or have deficiencies that would result in component failures if a demand had been received.
- Components fail within a selected period of time such that success of the PSA mission would be uncertain.
- Components fail because of a single shared cause and coupling mechanism.
- Components fail within the established component boundary.

A description of how CCF data are gathered, coded, and analyzed is presented in NUREG/CR-6268, Rev.1 [2]. The NRC provides CCF parameter estimates for industry PSA applications and to support the NRC's SPAR models. The results were originally published in NUREG/CR-5497 [3]. Quantitative results of this data collection effort are now presented annually on the NRC's website at http://nrcoe.inl.gov/resultsdb/ParamEstSpar/. The current report contains CCF data through 2012. INPO members and NRC staff may request access to the Common-Cause Failure Database (CCFDB). The CCFDB is a data collection and analysis system to support CCF parameter estimates. CCF data and analysis tools are also available to INPO members and NRC staff in the NRC Reactor Operating

Experience Data (NROD) website at https://nrod.inl.gov. The NROD website also provides a search feature for IDCCS coded data an enhanced web version of the Reliability and Availability Data System (RADS).

4.3. Loss of Offsite Power Study

Loss of offsite power (LOOP, also referred to as LOSP) events are important contributors to overall risk at nuclear power plants. Some U.S. commercial nuclear power plants attribute over 70% of the overall risk to LOOP events. The LOOP data covers both at power and shutdown operations. LOOP industry frequencies are determined for four LOOP event categories: plant-centered, switchyard-centered, grid-related, and weather related. Trend plots are provided for each LOOP category for both critical operations and shutdown operation. The LOOP report contains important PSA parameters such as bus probabilities and Emergency Diesel Generator (EDG) repair times and non-recovery probabilities. The LOOP report also contains an engineering analysis section that provided quantitative insights into LOOP causes. The NRC published NUREG/CR-5496 to provide updated LOOP model parameters, frequency, and recovery time data [4]. Updated results are published annually on the NRC's website at http://nrcoe.inl.gov/resultsdb/LOSP/. The current report contains results from 1986 to 2012.

4.4. Initiating Events Study

The NRC collects data for all unexpected reactor trips during power operations at commercial nuclear power plants. Each reactor scram is reviewed and categorized according to the initiating event. To be included in the study, an event must meet all the following criteria:

- Include an unplanned reactor trip (not a scheduled reactor trip)
- Sequence of events starts when the reactor is critical and at or above the point of adding heat
- Occurs at a U.S. commercial nuclear power plant
- Is reported by a Licensee Event Report (LER)

The operating data is used to determine trends or patterns of plant performance on a plant type, plant specific or industry-wide basis. The initiating events study is also used to validate the estimates used for PSA initiating event frequencies. NUREG/CR-5750 documents the results of the initial study [5]. Updates to the Initiating Events Study are posted annually on the NRC's website at http://nrcoe.inl.gov/resultsdb/InitEvent/. Initiating Event results through 2012 are currently presented.

4.5. System Studies

System performance evaluations have been made for select safety systems. For Boiling Water Reactors (BWRs), the available systems are:

- High Pressure Coolant Injection (HPCI) System
- High Pressure Core Spray (HPCS) System
- Isolation Condenser (IC) System
- Reactor Core Isolation Cooling (RCIC) System

For Pressurized Water Reactors (PWRs), the available systems are:

- Auxiliary Feedwater (AFW) System
- High Pressure Safety Injection (HPSI) System

Common available systems are:

- Emergency Power System (EPS)

- Residual Heat Removal System (RHR)

Reactor Protection Systems available for:

- General Electric
- Westinghouse
- Combustion Engineering
- Babcock and Wilcox (B&W)

The system studies provide unreliability results and trends for these given systems.
The initial system studies were documented in a series of NUREGs (NUREG/CR-5500, Volumes 1-11) [6]. Current results are posted on the NRC's website at http://nrcoe.inl.gov/resultsdb/SysStudy/.

4.6. Component Performance Studies

A study of safety-related components used in both PWRs and BWRs in risk important systems is provided. The study provides a risk-based analysis and engineering analysis of trends of operating data for select nuclear power plant components to provide insights into the performance of these components on an industry basis. The analyzed components are:

- Emergency Diesel Generators (EDGs)
- Turbine-Driven Pumps (TDPs)
- Motor-Driven Pumps (MDPs)
- Air-Operated Valves (AOVs)
- Motor-Operated Valves (MOVs)

The initial component performance studies were documented in a series of NUREGs (NUREG-1715, Volumes 1-4) [7]. Current results (through 2012) are posted on the NRC's website at http://nrcoe.inl.gov/resultsdb/CompPerf/.

4.7. Fire Events

The fire study uses operating experience data to characterize the frequency and nature of fire events from U.S. commercial nuclear power plants. The fire study contains data from 1987 to 2012 from various sources including LERs, ENs, EPIX data, Nuclear Plant Reliability Data System (NRPDS), and the National Electric Insurers Limited (NEIL). Some of these data sources have a limited time frame of contribution and fire events are not necessarily required to be reported through LERs and ENs. Due to the inconsistent data sources, the NRC fire events study should not be considered as comprehensive, rather only used for qualitative distribution and trending purposes. For quantitative fire data for use in PSA, the enhanced Fire Events Database (FEDB) developed by the Electric Power Research Institute (EPRI) in cooperation with the NRC should be used. The EPRI FEDB contains a complete and comprehensive data source of fire events at US nuclear power plants from 1990 through 2009 [8].

4.8. Industry Trends Program

The industry trends program was established to collect and monitor industry-wide data to ensure the nuclear industry is maintaining the safety performance of operating plants. The NRC reports annually to Congress the results of the ITP performance indicator trends. The current performance indicators included in the ITP are:

- Automatic Scrams While Critical
- Safety System Actuations (SSA)
- Significant Events

- Safety System Failures (SSF)
- Forced Outage Rate (FOR)
- Equipment Forced Outages per 1000 Commercial Critical Hours (EFO)
- Collective Radiation Exposure (CRE)
- Accident Sequence Precursors (ASP)
- Unplanned Power Changes
- Reactor Coolant System (RCS) Specific Activity
- Reactor Coolant System Leakage
- Drill/Exercise Performance
- Emergency Response Organization (ERO) Drill Participation
- Alert and Notification System Reliability
- Baseline Risk Index for Initiating Events (BRIIE)

A description of the ITP program as well as the results may be found at http://www.nrc.gov/reactors/operating/oversight/industry-trends.html

5. CONCLUSION

This paper provided a summary of operating experience data collection efforts performed by Idaho National Laboratory for the U.S. Nuclear Regulatory Commission. The results of this ongoing work were generally provided to the public through a series of NUREGs and currently through periodic web reports on the NRC's website. Several databases and data analysis tools are also provided for specific purposes. The operating experience data and data analysis tools provided by the NRC are available to support various PSA modeling needs.

Acknowledgements

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