STAFF RESPONSES TO PWROG PEER-REVIEW COMMENTS ON NRC SPAR PARAMETER DATA

This report summarizes the Nuclear Regulatory Commission's (NRC's) response to issues raised concerning parameters developed for use in probabilistic risk assessments (PRAs). In support of their concerns, the Pressurized Water Reactor Owners Group (PWROG) requested a series of four meetings between NRC staff and members of the PWROG to elaborate on their proposed suggestions towards improving NRC's operating experience (OpE) data analysis program, as contained in their associated report, entitled, "Component Reliability Data Issues for Discussion with NRC Research," PWROG-18029-NP (non-proprietary), Revision 1, Agency Documents Access and Management System (ADAMS) ML20279A597. The PWROG report represents the culmination of a significant industry assessment of the NRC's OpE Program managed by the Office of Nuclear Regulatory Research (RES).

The first meeting was held at NRC headquarters on January 7, 2020. At that meeting, the PWROG provided an overview of the issues raised in the PWROG report. The areas addressed represented a broad spectrum of issues in data reliability, common cause failure and uncertainty estimation, among other topics. Subsequent meetings on these same topics were held on March 19, 2020, April 9, 2020 and June 9, 2020 virtually using Skype. The meetings discussed a number of areas where the staff evaluates individual plant operating events, as available in the proprietary Institute for Nuclear Power Operations (INPO) Industry Reporting and Information System (IRIS) database and in licensee event reports (LERs). The operating events help form the basis for the parameters developed for use in PRAs such as the NRC's Standardized Plant Analysis Risk (SPAR) models as well as industry PRA models.

To facilitate discussions, the PWROG report also provided a peer review-type template that organized the issues into categories to facilitate NRC staff responses to the issues and to serve as a convenient means to enable potential future engagement.

The staff recognizes the need to maintain confidence in all aspects of the OpE data analysis program owing to both industry and staff reliance on it as a key input to quantitative risk models employed by both groups. As part of the resolution pathway, the staff has documented its findings using the aforementioned template to provide NRC responses in a convenient format and to promote continued and increasing confidence in the NRC OpE data analysis program which, itself, is an integral part of NRC's risk-informed regulatory oversight strategy.

Tables F-1 through F-4, in this report are adapted from the tables contained in Appendix F, "Observations Regarding NRC Reliability Dataset" PWROG-18029NP, Revision 1. The tables include the PWROG peer review comments, as summarized in the PWROG report appendix, and the addition of the column containing the NRC response to the observations.

- Table F-1: PWROG Peer Review Observations and NRC Responses Related to common cause failure (CCF) Issues (15 observations of common cause failure issues from CCF.1 to CCF.15)
- Table F-2: PWROG Peer Review Observations and NRC Responses Related to Data Quality (18 observations of data quality (DQ) issues from DQ1.1 to DQ9.1)
- Table F-3: PWROG Peer Review Observations and NRC Responses Related to Data Aging (5 observations of data aging (DA) issues from DA1.1 to DA5.1)
- Table F-4: PWROG Peer Review Observations and NRC Responses Related to Data

Classification (10 observations of data classification (DC) issues from DC1.1 to DC10.1)

The tables are similar to “Facts and Observations” as typically documented in nuclear industry peer reviews and include the following fields, all of which except the last one, were provided by the PWROG:

- **ID:** a code that helps to connect the observation to the original data issue
- **Observation:** a description of the data issue identified during the PWROG review of the NRC reliability datasets
- **Basis:** the criterion that the data issue is being judged against
- **Potential Resolutions:** PWROG proposed options for addressing and resolving the issue
- **References:** Appendices A through E in PWROG-18029-NP, Revision 1, provide more detail and examples to illustrate the issue. The references are:
    - Appendix A – original detailed documentation of each data issue
    - Appendix B – presentations from January 7, 2020 meeting with NRC
    - Appendix C – presentation from March 19, 2020 webinar with NRC
    - Appendix D – presentation from April 9, 2020 webinar with NRC
    - Appendix E – presentation from June 9, 2020 webinar with NRC
- **Priority:** PWROG ranking of the importance to utility PRAs: High (H), Medium (M), or Low (L)”
- **NRC Response/Resolution:** NRC response to PWROG observations and planned resolutions. NRC responses are made in close concert with advice provided by its primary data contractor, the Idaho National Laboratory (INL), who maintains the Industry Data Collection and Coding System (IDCCS) database and provides the underlying statistical and engineering support for the parameter development.

In addition to Tables F-1 through F-4, two additional tables are included here:

- Table DQ 1-1 documents the pairs of duplicate entries that contain different IDs as observed by PWROG. The column, “NRC Response,” was added to the table providing the NRC evaluation as to whether the pairs are duplicate entries. In the event of duplicate entries, the responses provide the resolution which is to remove the duplicates in the next parameter update.
- Table DQ 1-2 documents miscellaneous issues related to the 2015 NRC dataset observed by PWROG. The column, “NRC Response,” was added to document the NRC evaluation results and NRC actions planned.

This report constitutes the staff response to issues identified by the PWROG. As these issues are discussed further or as new issues are raised by the PWROG or other stakeholders, future revisions to this report or issuance of new reports may be considered.

Table F-1
PWROG Peer Review Observations and NRC Responses Related to CCF Issues

ID	Observation	Basis	Potential Resolutions	Ref	Priority	NRC Response/Resolution
CCF.1	The CCF Dataset (2015) includes a number of component-types that do not have equivalent entries in the NRC Dataset (2015). For example, the CCF Dataset includes heat exchangers for PWR, containment spray, BWR RHR, BWR isolation condenser, and CCW, while the NRC Dataset includes heat exchangers for pooled, CCW, and CCW non-extreme environment. This distinction in component-types is not consistent with the basic definition of the CCF parameters.	The common cause component-types and failure modes should be defined consistent with the component-types and failure modes in the reliability dataset.	Assure that component failure modes for which CCF parameters are calculated have equivalent entries in the component reliability dataset. If necessary, combine CCF component failure modes or create separate component reliability failure modes.	NEW	M	***AGREE: FUTURE ACTIVITY PLANNED*** Both the NRC parameter estimations in component reliability (or the NRC Dataset as called in the PWROG observation) and in CCF provide data needed by SPAR modelers (and senior reactor analysts). The reliability and CCF parameters usually have the same component-types and failure modes, but could vary with each other (e.g., with more, system-specific parameters for CCF) due to the needs from different SPAR models or specific case study and analysis. There should be no problem as long as the SPAR modelers can properly apply the right data to the corresponding basic events in the models. Considering modeling needs, the staff will make both datasets more consistent to each other going forward.
CCF.2	The prior distributions used for CC α factors are documented in Section 3.1.3 of NRC CCF (2015) but with very little explanation regarding how they were developed.	The prior distributions for CCF parameters are of critical importance for component failure modes where the data is sparse.	Provide clear documentation for the CCF prior distributions, including the source and bases for the distributions and any alternative distributions that were considered and rejected.	PWROG-18029, Appendix C (Slide 5)	M	***AGREE: ACTIVITY COMPLETED*** NRC understands the CCF prior documentation issue and has spent efforts to develop INL/LTD-17-43723 "Developing Generic Prior Distributions for Common Cause Failure Alpha factors and Causal Alpha factors" in November 2017. This report reviewed the existing process to develop generic prior distributions and developed new priors for alpha factors and causal alpha factors with data from 1997 to 2015. The report has been revised and is undergoing internal review prior to public distribution. In the meantime, A PSAM 14 conference paper "Developing Generic Prior Distributions for Common Cause Failure Alpha factors" was published in 2018 and publicly available for the CCF prior development.

ID	Observation	Basis	Potential Resolutions	Ref	Priority	NRC Response/Resolution
CCF.3	The prior distributions used to generate CCF α factors are critical for component failure modes where the data is sparse. However, the technical bases for creating such priors have not been developed.	The prior distributions for CCF parameters are of critical importance for component failure modes where the data is sparse.	Consider other approaches to generating CCF prior distributions. For example, develop multiple prior distributions, based on groupings of component failure modes that have some common attributes when CCFs are considered.	NEW	H	***AGREE: ACTIVITY COMPLETED*** Generic priors and cause-specific priors have been developed in the past few years. ***AGREE: FUTURE ACTIVITY PLANNED*** Component-specific priors are planned for development in 2022.
CCF.4	The prior distributions used for CC α factors, as documented in Section 3.1.3 of NRC CCF (2015), include extreme ranges of distributions from some common cause component grouping (CCCG) sizes and α factors. For example: a4 for CCCG=4 has a RF = (1.5e-2/3.8e-4) = 39.5. a6 for CCCG=6 has a RF = (2.4e-3/3.1e-7) = 7742. a8 for CCCG=8 has a RF = (6.0e-4/5.4e-11) = 1.1e7 These extreme ranges illustrate the lack of knowledge in the likelihood of common cause failures in large groups. It is not clear that such distributions are meaningful and whether Bayesian updating of such distributions is meaningful.	The prior distributions for CCF parameters are of critical importance for component failure modes where the data is sparse.	Consider other approaches to generating CC α factors, especially for large CCCGs and for component failure modes with sparse CCF data.	NEW	M	***AGREE: FUTURE ACTIVITY PLANNED*** NRC agrees that the prior distributions as well as the generic demand and rate distributions include extreme ranges of distributions for some CCCG sizes and alpha factors. NRC will investigate alternative approaches to better characterize the CCF parameter uncertainties. Suggestions from the industry are welcomed.

ID	Observation	Basis	Potential Resolutions	Ref	Priority	NRC Response/Resolution
CCF.5	The pooled distributions used for CC α factors, as documented in Sections 3.1.1 & of NRC CCF (2015), include extremely narrow ranges of distributions from some CCCG sizes and α actors (in comparison to the generic priors). For example, for "rate": a4 for CCCG=4 has a RF = (7.8e-3/ 5.4e-3) = 1.4 a6 for CCCG=6 has a RF = (3.1e-3/ 1.8e-3) = 1.7 a8 for CCCG=8 has a RF = (1.0e-3/ 4.3e-4) = 2.3 These pooled distributions do not account for the uncertainty due to the increased level of non-homogeneity in this data.	Component failure rate entries that pool data from diverse component types should account for the increased levels of non- homogeneity in the uncertainty distributions.	Revise the calculation of CCF parameters for pooled data so that the increased levels of non-homogeneity are better reflected in the uncertainty distributions.	NEW	M	***AGREE: FUTURE ACTIVITY PLANNED*** Same response and action item in CCF.4.
CCF.6	CCF events that occurred in lower operational modes (e.g., Mode 3, Mode 4) are categorized without any consideration of the lower likelihood that the event would have occurred during nominal full-power conditions. For example, CCF event #384. *CCF Event #384: Both EDGs unavailable due to improper switch position. This condition occurred during Modes 4 & 5 when much longer time is typically available to locally start the EDGs compared to Mode 1. The condition was recognized and corrected within 7 hours.*	Weighting factors should be applied to each CCF event to properly account for its applicability to baseline PRA models.	Include a weighting factor that accounts for the reduced likelihood that the event at lower operational modes would have occurred during nominal full-power conditions.	PWROG-18029, Appendix D, CCF Events	M	***DISAGREE: NO CHANGES PLANNED*** The NRC CCF database includes a field for the CCF event operational status that indicates when the CCF event occurred or could occur. For example, a CCF event could be detected during plant shutdown but could occur during both power operations and shutdown conditions. We do not quantify the likelihood of a shutdown event could occur during power operations though. The PWROG example does not explain how the CCF event could have a lower likelihood to occur during power operations. We are currently not considering revising the CCF coding and parameter calculating process as proposed by the PWROG.
CCF.7	It is not clear how CCF events that occur due to debris in the UHS are modeled to account for the environmental condition. For example, CCF event #515. *CCF Event #515: Circ water traveling screens C and D failed due to sheared pin. The failures occurred during a seaweed intrusion. The pins were an incorrect size.*	Weighting factors should be applied to each CCF event to properly account for its applicability to baseline PRA models.	Provide an explanation for how CCF events that involve environmental conditions are expected to be used. For example, would the system model include the likelihood of the extreme environmental condition by modeling this as an initiating event (e.g., loss of circulating water)?	PWROG-18029, Appendix D, CCF Events	M	***AGREE: ACTIVITY PLANNED*** NRC is developing a report of "Loss of Service Water Quantification 1998 to 2019". This item will be closed upon the completion of the report.

ID	Observation	Basis	Potential Resolutions	Ref	Priority	NRC Response/Resolution
CCF.8	CCF event #520 (see below) includes use of the Failure Mode Applicability factor (0.1). Since this appears to be the only CCF event that uses this factor, it is not clear what condition it is accounting for. *CCF Event #520: RHR pump A and C minimum flow valves were found sealed shut rather than sealed open. This was corrected in a timely fashion due to the associated LCO, with the entire Inoperable time lasting about 3 hours.*	Weighting factors should be applied to each CCF event to properly account for its applicability to baseline PRA models.	Document how the Failure Mode Applicability factor is defined and used in CCF event weighting. Consider expanding the use of the Failure Mode Applicability factor to other CCF events.	PWROG-18029, Appendix D, CCF Events	M	***AGREE: ACTIVITY COMPLETED*** Section 5.1.16 of NUREG/CR-6268 describes that "Failure mode applicability represents the percentage of specific failure modes for multiple component failures involved in the CCF event. This is a weighting factor for parameter estimation for a CCF event involving multiple failure modes..." For CCF event #520, the Failure Mode Applicability Factor of 0.1 was coded incorrectly and was switched to 1.0 based on LER 2982017001.
CCF.9	CCF event #526 (see below) includes P_values of 0.5 for all three (3) components. However, it is not clear what the bases for these values are, except for the potential for recovery. *CCF Event #526: Failed Programmable Logic Controllers affects all 3 SBO diesels. During initial troubleshooting, it "appeared" that the SBO diesels were able to be started at the human machine interface (HMI). The HMI did not indicate the ability to close any of the breakers on the PB bus. The physical Lower Medium Voltage Sys 4.16 KV Bus breakers have the capability of being closed via mechanical push buttons, but there are no site procedures that provide guidance to do so.*	Weighting factors should be applied to each CCF event to properly account for its applicability to baseline PRA models.	Provide an explanation for how the P_values were selected for this CCF event. If it is based on recovery potential, consider expanding that use to other highly recoverable CCF events.	PWROG-18029, Appendix D, CCF Events	M	***DISAGREE: NO CHANGES PLANNED*** The P_values were not based on the potential for recovery, but rather because the event was more a degradation condition than a full failure. For the suggestion to use weighting factors for highly recoverable CCF events, NRC does not agree with introducing recovery actions and their likelihood as weighting factors in CCF (or reliability) parameter estimation. Instead, it may be more proper for recovery actions, including recovery probabilities, to be considered during the PRA model development phase. For the CCF Event #526, the EPIX record stated that "The Fix It Now (FIN) team reset both SBO PLCs which cleared the alarm condition and put the SBO in a functional but degraded state." The p-value code is supposed to be used specifically to address degradation and not potential recovery. The EPIX record states that the SBO diesel was degraded and that the utility was unable to restore the diesel until support from vendor was provided. Potential recovery does not appear to be the case.

ID	Observation	Basis	Potential Resolutions	Ref	Priority	NRC Response/Resolution
CCF.10	CCF event #525 (see below) includes P_values of 1.0 for both components. However, it is clear from the event description that these failures were recoverable within 30 minutes. *CCF Event #525: During the start of Unit 1 B EDG, the air start valves failed to close. This depressurized the common air start header 1B EDG shares with Unit 2 A and B EDGs. Failure of newly-installed diodes for the 1B EDG was the cause, which exploited an original design vulnerability of having a common header. Operators were able to quickly isolate the 1B air start control valve, allowing pressure to recover for the Unit 2 EDGs (within 30 minutes).*	Weighting factors should be applied to each CCF event to properly account for its applicability to baseline PRA models.	Consider expanding the use of P_values to account for highly recoverable CCF events.	PWROG-18029, Appendix D, CCF Events	M	***DISAGREE: NO CHANGES PLANNED*** Same response as in CCF.9.
CCF.11	CCF event #534 (see below) is classified as a failure of both MFW pumps. However, the event is described as a failure due to a common support system, instrument air. *CCF Event #534: Both MFPs tripped on low suction pressure. Loss of IA pressure to the condensate demin. system due to catastrophic failure of the inline air filter bowl was the cause.*	Events should be excluded from the generic CCF dataset if they can be accounted for in the generic initiating event dataset.	Remove this event from the CCF dataset since it should be included as a Loss of Main Feedwater (or Loss of Instrument Air) initiating event.	PWROG-18029, Appendix D, CCF Events	M	***DISAGREE: NO CHANGES PLANNED*** NRC does not agree that a CCF event should be removed from the CCF dataset if it is accounted for in initiating event dataset. Such CCF events should be included in order to provide correct estimation for the CCF parameters.
CCF.12	Many of the CCF events with CCCGs > 4 involve main steam safety or relief valves. Most of those events are due to setpoint failures (e.g., see CCF event #491, below). This failure mode appears to be unique to safety and relief valves and, thus, does not provide insights into the likelihood of common cause failures in large CCCGs involving other component-types. *CCF Event #491: Corrosion bounding of three MSSVs. Results in high OOS setpoints (3 of 12, with P_values of 1.0).*	CCF events should be pooled only when the failure causes included could be generally applicable to all component-types included in the pooled data.	In the creation of large pooled groups (e.g., all “demand” CCFs), do not pool CCF events when the failure causes are not generally applicable to the component- types included in the pooled data. For example, do not pool CCF events involving main steam safety or relief valves with other component-types when calculating CCF parameters for large-pooled groups.	NEW	M	***AGREE: NO CHANGES PLANNED*** We agree that setpoint failure is a different failure mode from fail to open and fail to close. No changes are planned as the setpoint CCF events are included in the NRC CCF database but not used in CCF parameter estimation.

ID	Observation	Basis	Potential Resolutions	Ref	Priority	NRC Response/Resolution
CCF.13	For CCF events due to setpoint failures (e.g., see CCF event #491 in CCF.12), it is not clear that these events were, in all cases, functional failures of the safety/relief valves.	CCF events should be evaluated to determine whether the event is a functional failure.	Review CCF events involving safety/relief valves to determine whether the events are functional failures. Where there is uncertainty about the impact of the event, use P_values to appropriately weight each event.	NEW	M	***DISAGREE: NO CHANGES PLANNED*** See the above response to CCF.12.
CCF.14	A number of CCF events at dual units account only for the size of the CCCG in the unit with the CCF. For example, CCF event #489 (see below) includes only the 3 EDGs in Unit 2, not the additional 3 EDGs in Unit 1. *CCF Event #489: 2/3 EDGs inoperable due to failed cylinder cap-screws.*	The CCCG for each CCF event should include all component-types in the same system in all units on the site.	Review CCF events for sites with more than one unit and revise the CCCG size, as necessary, to account for all similar component-types in the same system on site.	NEW	M	***DISAGREE: NO CHANGES PLANNED*** The current NRC CCF characterization process does not include the identification of inter-system or multi-unit CCFs. The CCCGs are thus not determined by the size across units.

Table F-2
PWROG Peer Review Observations and NRC Responses Related to Data Quality

ID	Observation	Basis	Potential Resolutions	Ref	Priority	NRC Response/Resolution
DQ1.1	A number of editorial errors were identified with the NRC Dataset (2015) that have the potential to impact how the data are used. These include duplicate entries (e.g., PLF FTOP and PLL FTOP have exactly the same success and failure data), documentation errors in the Data Source and Comment fields, and entries labeled fail-to-start but identified as per-hour rather than per-demand. See Tables DQ.1-1 and DQ.1-2 for additional editorial errors.	Documentation of the methodology and results of the generic data analysis should be accurate and complete.	Review the 2020 dataset to assure that these (or similar) editorial errors are not present.	PWROG-18029, Tables DQ.1-1, DQ.1-2	M	***AGREE: ACTIVITY COMPLETED*** NRC appreciates the peer review of the NRC Dataset by the PWROG. Please see the NRC review results for each of the identified issues in the attached Tables DQ.1-1 and 1.2, as well as the actions in the 2020 parameter update efforts. For 19 pairs of duplicate entries identified in Table DQ.1-1, 10 of them have no data issues. Nine pairs had duplication issue and were corrected in the 2020 Update. For 39 entries of miscellaneous issues identified in Table DQ.1-2, 24 of them had no data issues. Fifteen had data issues which were corrected in the 2020 Update.
DQ1.2	Potential editorial errors were identified with the NRC Dataset (2015) related to questionable number of demands and run-hours. For example: TDP-FS-NR-MFW (MFW turbine driven pump fails to start, normally running) is listed as having almost 6E+6 demands for 43 pumps over the 17-year period from 1998 to 2015. These potential errors are identified in the last column in Table DQ.1-2 of PWROG-18029 as “Questionable # of demands” or “# of run-hours seems to be too high”.	Documentation of the methodology and results of the generic data analysis should be accurate and complete.	Review (and correct as needed) the questionable number of demands and run- hours to determine whether these are simply editorial errors that do not impact the failure rates, errors that may impact the failure rates, or technical issues that need to be investigated and resolved.	PWROG-18029, Table DQ.1-2	H	***AGREE: ACTIVITY COMPLETED*** Same response as DQ 1.1.

ID	Observation	Basis	Potential Resolutions	Ref	Priority	NRC Response/Resolution
DQ2.1	The NRC Dataset (2015) and NRC CCF Dataset (2015) are not consistent in the number of failure events for some component failure modes. Also, these two datasets do not quite match for event dates included. NRC dataset covers 1998 to 2015. NRC CCF Dataset (2015) covers 1997 to 2015. However, it is not clear the one additional year of data for NRC CCF explains the differences. For example, EDG FTS has an annual average number of failures of 11.9 in the NRC Dataset vs 13.8 in the NRC CCF Dataset.	The generic reliability dataset and CCF dataset should be consistent in time period of the data and the total number of failure events for each component failure mode.	Assure that the NRC Dataset (2020) and NRC CCF Dataset (2020) are consistent in the date range of data included. Verify that the count of failure events is consistent between these databases or explain the reasons for any differences.	PWROG-18029, Table DQ.2-1	H	***(1) AGREE: ACTIVITY COMPLETED*** For the different date ranges in the NRC Dataset (2015) and NRC CCF Dataset (2015), while staff does not think it would have adverse impact on the results, we agree that it is a good practice to use the same or similar date ranges for them. The same date range has been used in the 2020 parameter update for both component reliability and CCF analysis. ***(2) DISAGREE: NO CHANGES PLANNED*** The different number of failure events for some component failure modes in the NRC Dataset, CCF Dataset, and NRC Reactor Operating Experience Data (NROD), may be expected because these datasets have different purposes and thus have different search results. For example, NROD returns all failure events meeting the search criteria (date range, component type, failure mode, etc.). The NRC Dataset and CCF Dataset only use those NROD events for which devices are identified in the device list. The NRC Dataset uses only the complete failure events (i.e., P value equals to 1) while the CCF Dataset includes failure events with P_values of 0.1 and 0.5. For example, EDG FTS has approximately 260 events in NROD from 1998-2015, of which approximately 240 are in the device list but only approximately 210 are complete failures.
DQ2.2	Inconsistencies in the number of failure events for some component failure modes were noted among the sources of 2015 NRC reliability data: ▪ Datasheets ▪ Spreadsheet ▪ NROD See Table DQ.2-1 for examples of inconsistencies. Also see Observation DC5.4.	Documentation of reliability datasets should be consistent with the NROD database.	Resolve the inconsistencies in the 2020 datasets or explain the reasons for potential inconsistencies and how the data should be used (e.g., whether the spreadsheet results should be used when in disagreement with the datasheets).	PWROG-18029, Appendix A, DQ.2	M	***DISAGREE: NO CHANGES PLANNED*** See the response #2 in DQ2.1. The different numbers between NROD and datasheets/spreadsheet are typically expected and reasonable due to their different purposes. However, in the event inconsistencies between NROD and RADS are identified, for instance, for results on batteries failing to operate, we will investigate and make proper corrections, as needed.

ID	Observation	Basis	Potential Resolutions	Ref	Priority	NRC Response/Resolution
DQ3.1	The component boundaries between NRC Dataset (2015) (as defined in NUREG/CR- 6928) and NRC CCF Dataset (2015) should be consistent. However, NUREG/CR-6928 and NRC CCF Dataset (2015) are not consistent in at least one important component boundary, EDGs. In Section 5.1 of NUREG/CR-6928, room cooling is excluded from the EDG component boundary while in NRC CCF Dataset (2015), heating, ventilation and AC are within the EDG boundary.	The definitions of component boundaries should be consistent between these datasets since these are used to calculate the inter-related component failure rates and the CCF parameters.	Verify that the component boundaries are consistent between the reliability dataset and the CCF dataset for 2020. Where differences are identified, use the boundary definitions from NUREG/CR-6928 in both datasets.	PWROG-18029, Appendix A, DQ.3	M	**DISAGREE: NO CHANGES PLANNED** The NRC Dataset (2015) and the CCF Dataset (2015) used the same component failure database with the same component boundaries. Uncertain where “heating, ventilation and AC” are listed as being within the EDG boundary.
DQ4.1	NRC datasets from 2007, 2010 and 2015 show significant changes in some component failure rate mean values. It is not clear whether these are based on changes in average component performance, changes in failure data collection or data treatment, or changes in estimates of success data. For example, CRD-FTOP (control rod fail to insert rod), the mean value changed from 1.32e-5/d (2007) to 9.91e-8/hr. (2010) to 1.15e-7/d (2015).	Documentation of the methodology and results of the generic data analysis should be accurate and complete.	Document the basis for any significant changes in the ways specific component failure modes are defined or their failure rates calculated.	PWROG-18029, Section 5; Appendix A, DQ.4	M	***AGREE: FUTURE ACTIVITY PLANNED*** When NRC updated the industry-average parameter estimates, the preliminary results were reviewed both by the data analysts and the SPAR modeler group for significant changes compared to previous dataset as well as unexpected results. A summary of the top 10 increased/decreased unreliability estimates is provided in the Component Reliability Data Sheet for the latest update. In the pending update, NRC will include the main changes (both methodologies and results) in its update documentation.
DQ4.2	The estimation of success data is an important element in calculating failure rates since the success data reported to INPO is not always done in a consistent manner by each utility (based on PWROG investigations). However, no documentation was found that explained the process for developing success data to support the NRC datasets.	Documentation of the methodology and results of the generic data analysis should be accurate and complete.	Document the bases for estimating success data for the calculation of generic failure rates. It might be sufficient to describe the general methods used, with some examples to provide the detail.	NEW	L	***DISAGREE: NO CHANGES PLANNED*** Staff agrees that the success data is important in data analysis, but has assumed that there was little to no confusion as to how it should be defined

ID	Observation	Basis	Potential Resolutions	Ref	Priority	NRC Response/Resolution
DQ5.1	MDP-SBY group includes pumps that are always in standby (e.g., containment spray pumps, HPI pumps) and pumps that are normally standby but have a normal operational mode (e.g., RHR pumps, AFW pumps). Pumps always in standby would be expected to have much fewer run-hours per start compared to the second group. (Note, the inclusion of pumps that are normally standby but have a normal operational mode explains the original issue identified in PWROG-18029, Issue DQ.5, that run-hours for Standby Motor-Driven Pumps appear to be excessive.)	Component-types should be grouped on common attributes that may impact estimates of component reliability.	Several potential resolutions are suggested: Create two (2) groups, MDP-SBY and MDP-SBY-NO, to model these pumps in more homogeneous groups. Use the average number of run-hours per start as a metric to determine the pumps that should be included in each group. Group pump types based on other attributes (e.g., high pressure vs low pressure). Group pump types based on their system (e.g., MD-AFW pumps, RHR pumps) where sufficient data is available.	PWROG-18029, Appendix E (Slide 6)	M	***DISAGREE: NO CHANGES PLANNED*** Distinguishing between standby components and normally running components is frequently a challenge in nuclear data analysis. Sections 5.4 and A.1.2 of NUREG/CR-6928 explain the process to divide components into standby versus running/alternating categories: (1) the components were sorted by run hours, (2) components with run hours fewer than 10% of calendar hours were placed in the standby category, and (3) components with more run hours than in item (2) above were placed in the running/alternating category. The use of the 10% cutoff was based on a review of run hours for components in systems known to have only standby components (The highest result among such systems was about 8% and most system results less than 3%.)

ID	Observation	Basis	Potential Resolutions	Ref	Priority	NRC Response/Resolution
DQ5.2	The justifications for separating short-term and long-term run failure rates for standby components are inadequate. For example: For many standby components, long-term- run failure rates are not lower than short- term, inconsistent with what one might expect. Limited long-term run data are available for truly “standby” components (e.g., PDP- SBY, positive displacement pumps) since test runs are typically no longer than 1 hour. For other components classified as Standby, the long-term-run success data is much greater than the short-term-run data (e.g., ACX-FTS, Air Cooling Heat Exchanger, Normally Standby). For some components, the data (failures, run-hours) appear to have been split evenly between short-term-run and long-term-run (e.g., CHL, Chiller Unit, Normally Standby). It is difficult to determine whether failure events are actually short-term or long-term.	Component failure modes should be separated only if the data supports the sub-dividing.	Combine short-term-run and long-term-run data for standby components where the data does not support separate failure modes.	PWROG-18029, Appendix E (Slides 7, 12-15)	H	***DISAGREE: NO CHANGES PLANNED*** Use of short-term and long-term run failure rates for standby components such as MDPs and EDGs are long-time practices in PRA modeling and data analysis. It was deemed in NUREG/CR-6928 as “a fundamental improvement in SPAR model basic event parameter estimation”. A review of the recent parameter update results shows that MDP, EDG, FAN, CTF and other component types are still having larger early run failure rates, while TDP, EDP, PDP, and CTG have lower early run failure rates. With no plan to change the SPAR modeling practice, we will continue to provide short-term and long-term run failure rates similar to previous parameter updates.

ID	Observation	Basis	Potential Resolutions	Ref	Priority	NRC Response/Resolution
DQ5.3	Based on a review of a sample of failure events included in the short-term-run failure mode (Fail to run < 1H) for standby components, it appears that some failure events should be classified as demand-based rather than time-based events.	Failure events should be classified as demand-based or time-based using standard definitions for fail-to-start and fail-to-run failure modes.	Define (or refine the definitions for) failure modes for event classification: Fail to Start: failure to reach a stable running state within a few minutes of start demand (demand failure). Fail to Run: failure to continue to run after reaching a stable running state (run failure). Review the standby component failure events classified as “Fail to run < 1H” in light of these definitions and reclassify as appropriate.	PWROG-18029, Appendix E (Slides 8, 9)	H	***DISAGREE: NO CHANGES PLANNED*** The IDCCS Coding Manual includes the definitions for EDG FTS/FTLR/FTR and pump failure on demand/failure to run. It defines “Pump failure on demand: A failure to start and run for at least one hour is counted as failure on demand.” The demand failures should be if it fails to run less than an hour. Sometimes timing isn’t mentioned so we have to make an assumption based on the verbiage used as to whether it is a run failure vs a start failure. If the industry has different opinions on some of the event characterization, please provide support information and we can re-consider coding, if needed.

ID	Observation	Basis	Potential Resolutions	Ref	Priority	NRC Response/Resolution
DQ5.4	Based on a review of a sample of failure events included in the load-run failure mode (FTLR) for generators (EDG, CTG and HTG), it appears that some failure events should be classified as demand-based rather than time-based events.	Failure events should be classified as demand-based or time-based using standard definitions for fail-to-start, fail-to-load, and fail-to-run failure modes.	For generators, revise failure definitions to clarify demand-failures from run-failures: FTS: failure to reach a stable start-run state. A stable start-run state includes adequate starting air to roll the EDG; automatic start from an undervoltage signal or test start from the main control room; and reaching normal and stable speed. FTL: failure to reach a stable load-run state. A stable load-run state includes EDG output breaker closed, stable engine speed, generator field successfully flashes, stable output voltage & frequency, carrying full capacity load, and cooling flow established. FTR: failure to continue to run after reaching a stable running (or load-run) state. Review the standby component failure events classified as “Fail to load/run < 1H” in light of these definitions and reclassify as appropriate.	PWROG-18029, Appendix E (Slide 10)	H	***DISAGREE: NO CHANGES PLANNED*** Same as DQ 5.3. Please provide supporting information if specific classification issues are identified.

ID	Observation	Basis	Potential Resolutions	Ref	Priority	NRC Response/Resolution
DQ5.5	Based on a review of a sample of failure events included in the EDG-FTLR failure mode, this is a mix of demand-failures (fail to load) and run- failures.	Component failure modes should be clearly defined as demand-based or time-based failures.	Use the revised failure definitions (provided in DQ5.4) to clarify demand-failures from run- failures in FTL. Replace FTLR with FTL, where FTL is defined as a demand failure mode. Review the previous FTLR failure events using new definition of FTL and include only the demand-based failures in FTL. Move any run-failure events in the FTLR failure mode to FTR. Calculate FTR using all run-failure events and all run-hours.	P5WROG-18026, Appendix E (Slide 11)	H	**DISAGREE: NO CHANGES PLANNED** FTLR = "Given that it has successfully started (FTLR is) a failure of the EDG output breaker to close, to successfully load sequence and to run/operate for one hour to perform its monitored functions. This failure mode is treated as a demand failure for calculational purposes. (Exclude post maintenance tests, unless the cause of failure was independent of the maintenance performed.)" Note that this is consistent with the guideline in INPO-12-009 and INPO-19-002 for reporting requirements. (Also, there is no specific code for FTL it is only FTS, FTR, and FTLR.) Contact NRC if specific classification issues are identified.
DQ6.1	The FLOW sensor/transmitter failure rates (STF FTOP-D, STF FTOP-R) are based on the LEVEL sensor/transmitter event data (STL FTOP-D, STL FTOP-R) in NUREG/CR-6928 (from NUREG/CR-5500). However, no justification is provided for this treatment.	Documentation of the methodology and results of the generic data analysis should be accurate and complete.	Develop failure rates specifically for FLOW process logic and FLOW sensors/transmitters based on recent failure event data (2006 to 2015). If that change is not possible in the near term, at least provide a basis for the use of LEVEL data (rather than pressure or temperature) as an appropriate surrogate for FLOW sensors.	PWROG-18029, Appendix A, DQ.6	L	***DISAGREE: NO CHANGES PLANNED*** There is no EPIX/IRIS data provided by industry to conduct specific analysis. Engineering judgement was used for the Level sensor/transmitter failure data and for those of the Flow sensor/transmitter.

ID	Observation	Basis	Potential Resolutions	Ref	Priority	NRC Response/Resolution
DQ7.1	<u>Basis for Error Factors</u>: Data distributions in the NRC Dataset (2015) may not fully account for the uncertainties in the failure rate estimates. Specifically, distributions based on JNID/IL (Jeffreys non-informative distribution at the industry level) fail to account for the differences in the number of success events (or success-hours). For example, the error factor for component failure modes with zero failure events is 8.4, while the number of successes range from 78 to 7.2E7.	Generic data distributions should account for all contributors to uncertainty.	Where JNID/IL is used, develop a method for accounting for the number of success events in the calculation of the error factor.	PWROG-18029, Appendix A, DQ.7; Appendix B.3 (Slides 4, 5)	M	***AGREE: FUTURE ACTIVITY PLANNED*** NRC will coordinate with statisticians and industry on how to better characterize error factors and uncertainty associated with various failure/success data.
DQ7.2	<u>Basis for Error Factors</u>: Data distributions in the NRC Dataset (2015) may not fully account for the uncertainties in the failure rate estimates. While a number of component failure modes account for plant-to-plant variability by using EB/PL/KS (plant-level empirical Bayes statistical analyses with the Kass-Steffey adjustment), other contributions to uncertainties are not reflected in the distributions based on the raw number of failures and successes for a specific component failure mode. These could include: Uncertainty in the number of failure events and number of demands or run times Uncertainty in the type and consequence of the failure event Uncertainty in the homogeneity of components in the group based on component attributes such as manufacturer, size, process fluid, ambient environment, etc. Uncertainty in the homogeneity of components based on plant-to-plant variability.	Generic data distributions should account for all contributors to uncertainty.	Develop a method of accounting for an expanded set of contributors to the uncertainty that underlie the inputs into failure rates (and CCF parameters). It may be important to classify the types of uncertainties (e.g., random, state-of-knowledge, fuzziness) to fully account for the underlying uncertainties in data distributions and to better account for the state-of- knowledge correlation.	PWROG-18029, Appendix A, DQ.7; Appendix B.3 (Slides 4 to 10).	L	***AGREE: FUTURE ACTIVITY PLANNED*** Same as in DQ7.1.

ID	Observation	Basis	Potential Resolutions	Ref	Priority	NRC Response/Resolution
DQ7.3	The process of treating data using plant-level empirical Bayes method generally includes a pooling analysis to justify the grouping. NUREG/CR-6928 documented the original pooling analysis. However, no documentation of pooling analysis could be identified for the 2015 dataset.	Documentation of the methodology and results of the generic data analysis should be accurate and complete.	Document the pooling analysis that justified the grouping of data for each component-type and failure mode.	NEW	L	***DISAGREE: NO CHANGES PLANNED*** The 2015 and beyond datasets are updates of NUREG/CR-6928 with generally the same processes/methodologies as those in the original NUREG/CR report. If the update reports do not have statement indicating a change, it would mean the same processes/methodologies have been used in the updates.
DQ8.1	CCF Weighting Factors & Mapping-Up Process: NUREG/CR-6268 documents the CCF database and analysis system set up by INL for NRC. The NUREG suggests various weighting factors that are incorporated via the database for events based on uncertainty in Timing, Component Degradation, and Shared Cause. Three (3) additional factors are used in assessing CCF failure events: Shock Type, Failure Mode Applicability, and Defense Mechanism. However, it is not clear how these factors are used to create CCF parameters and their uncertainty distributions.	Documentation of the methodology and results of the generic CCF data analysis should be accurate and complete.	Create a detailed methodology guideline that provides the details regarding how the NUREG method gets implemented in the NROD/RADS PRA Calculator. This should include specifically how weighting values and mapping-up values are created. Example calculations would be helpful to explain the details.	PWROG-18029, Appendix A, DQ.8; Appendix C (Slide 5)	M	***DISAGREE: NO CHANGES PLANNED*** NUREG/CR-6268, Rev. 1, provides documentation on how the CCF weighting factors and the mapping-up process are used in CCF parameter estimations.
DQ9.1	The PWROG review of the 2015 NRC reliability datasets has been based on implicit criteria for what constitutes high quality generic reliability datasets. However, no explicit criteria exist that would support systematic reviews in the future (as well as future updates to these datasets). For example, supporting requirement DA-C1 from the PRA Standard (Addendum B) states, "USE generic parameter estimates from recognized sources…" and includes NUREG/CR-6928 as an example of "recognized source" for component failure rates. There are no criteria specified except that these be recognized sources.	Explicit criteria documenting the elements of a high-quality generic reliability dataset would help support a systematic review. Criteria could provide structure to the review as well as identifying important elements that could be included.	Develop explicit criteria documenting the elements of a high-quality generic reliability dataset to support future updates and peer reviews.	NEW	L	Developing such criteria is unrelated to NRC data collection and analytics activities but the industry may consider developing criteria to benefit future peer-reviews.

Table F-3
PWROG Peer Review Observations and NRC Responses Related to Data Aging

ID	Observation	Basis	Potential Resolutions	Ref	Priority	NRC Response/Resolution
DA1.1	Time Trends of Component Failure Events: The current NRC Dataset (2015) includes data for a 20-year period, 1996 to 2015. However, the average performance of components industry-wide is significantly better in the most recent 10-year period compared to earlier time periods. The most recent decade would be more indicative of near-term future component performance.	Component reliability over the recent past should be the best estimator of future performance. The time period used for component reliability data needs to balance the value of recent past data with the need for adequate amounts of data.	Use the data from the most recent time period to calculate generic failure rates. The length of this time period should be short enough to reflect recent component performance (e.g., 2009 to 2019) but may need to be extended for some components where failure events are rare. The time periods used should be consistently used in the generic CCF parameter calculations (see Observation DA2.1).	PWROG-18029, Appendix A, DA.1; Appendix C (Slide 9)	H	***AGREE: FUTURE ACTIVITY PLANNED*** NRC has evaluated whether using a shorter, more recent time period for parameter estimate is appropriate and could better reflect the current industry performance. The NRC determined that updates will use a 15-yr rolling period to estimate component reliability and CCF parameters.
DA2.1	Time Trends of CCF Events: The current NRC CCF Dataset (2015) includes data for a 19-year period, 1997 to 2015. The NROD Database includes CCF events from 1996 to 2019. However, the average performance of components industry-wide as measured by CCF data is significantly better in the most recent 10-year period compared to earlier time periods.	Component reliability over the recent past should be the best estimator of future performance. The time period used for component reliability data needs to balance the value of recent past data with the need for adequate amounts of data. The time periods for generic reliability data and CCF data should be consistent for each component failure mode.	Use the data from the most recent time period to calculate generic CCF parameters. The length of this time period should be short enough to reflect recent component performance (e.g., 2009 through 2019) but may need to be extended for some components where common cause failure events are rare. The time periods used should be consistently used in the generic component failure rate calculations (see Observation DA1.1).	PWROG-18029, Appendix A, DA.2; Appendix C (Slide 6)	H	***AGREE: FUTURE ACTIVITY PLANNED*** See the response in DA1.1.

ID	Observation	Basis	Potential Resolutions	Ref	Priority	NRC Response/Resolution
DA3.1	<u>Failure Rates Based on Old Data</u>: Of the 332 component failure rates in the NRC Dataset (2015), 70 are based on old data: *Large internal/external leaks (38) – from EPIX, 1997 to 2004.* While the small leakage events have been updated to 2015, the large leakage rates are still based on the factors developed from the 1997 to 2004 EPIX data. *Pipe leaks (4) – from EPIX, 1997 to 2004.* PIPE SWS-ELS and PIPE OTHER-ELS are based on data. The ELL failure rates are based on the ELS failure rates times α factor (0.2 for SWS, 0.1 for Other). *Control circuit failures (3) – from WSRV, 1980s to 1990.* The NRC Dataset (2015) labels the source of these component failure modes (ICC-FA, ICC-FC, ACT-FC) as NUCLARR but the Datasheets identify the source as WSRC. *Air dryer unit (1) – from WSRV, 1980s to 1990.* The NRC Dataset (2015) labels the source of this component failure mode, ADU-FTOP, as NUREG/CR-6928 but the Datasheets identify the source as WSRC. *Orifice plugging (1) – from WSRV, 1980s to 1990.* The failure rate for this component failure mode, ORF-PG, comes from the Westinghouse Savannah River Company (WSRC) database. Sensors, bistable, manual switch, process logic, RPS breaker (19) – from NUREG/CR-5500, 1984-1995. See Observation DA5.1 PORV (4) – special calc, from NUREG/CR-7037, 1987 to 2007. See Observation DA4.1.	Generic component failure rates should be based on recent reliability data for each component failure mode.	Delete external leakage and pipe leakage failure modes from the 2020 NRC Dataset since those failure modes are addressed in internal flood datasets (see Observations DC2.1 and DC4.1). Eliminate WSRV-based data for the five (5) component failure modes that use this source based on its age and lack of availability of the source data. If failure rates for these component failure modes are required, consider creating failure rates from “similar equipment” (per requirement DA-D2 in the PRA Standard). In general, where recent reliability data are not available, use other techniques (e.g., expert elicitation) to develop appropriate failure rate distributions.	PWROG-18029, Appendix A, DA.3	M	***DISAGREE: NO CHANGES PLANNED*** The results from NUREG/CR-6928 and subsequent updates have been used as inputs to the SPAR models. Unless the associated component failure mode data are no longer needed by SPAR models, such parameter estimates will, of necessity, continue to be provided based on the best available data. It is true that other techniques such as expert elicitation could be used to replace the results from old data, but the resources needed for these efforts must be commensurate with the risk significance of the associated component failure modes.

ID	Observation	Basis	Potential Resolutions	Ref	Priority	NRC Response/Resolution
DA4.1	Failure Rates for Safety Valve Fail to Reclose Based on Judgment: NUREG/CR-6928 included Safety Valve and Safety Relief Valve failure to reclose passing liquid (SVV FTCL, SVR FTCL) with a mean value of 0.1, based on judgment with very limited basis. NRC Dataset (2015) eliminated these failure modes. It includes a new failure mode, *PORV-Liquid,* with mean value of 6.25E-2, given the evidence of zero failures and seven demands from 1987 to 2007 (from NUREG/CR-7037).	Generic component failure rates should be based on recent reliability data for each component failure mode. Where recent reliability data are not available, use other techniques (e.g., expert elicitation) to develop appropriate failure rate distributions.	Update the component failure mode *PORV- Liquid* with recent failure event data since the basis for this is old and very limited data with zero failures. Consider use of expert elicitation for this component failure rate if data continues to be sparse.	PWROG-18029, Appendix A, DA.4; Appendix C (Slide 18)	M	***AGREE: FUTURE ACTIVITY TO BE CONSIDERED*** The inclusion of aged data (1980s – early 1990s) or older studies (such as RPS system study or Westinghouse Savana River Complex) in NUREG/CR-6928 and its updates is due to one of the following reasons: (1) the data is not available from EPIX or LER review or (2) the data is available but sparse. As PWROG suggested, there are two ways to address the data aging issue: either collect recent failure data or use other approaches such as expert elicitation. The collection of more and better failure data will require effort on the part of the industry and the NRC. The industry could report such data directly to INPO (voluntarily or required by INPO reporting requirements) or it could include the demand and success/failure information in LERs or other forms of reporting. An example of this is PWR RCS safety valves open and reclose status. If done, NRC could better characterize and classify such events/data for analysis. Expert elicitation could be another approach to address sparse data issue, but it would need even more effort from the industry and NRC. This approach should be reserved for the most important component failure mode parameters (which could be determined by a joint industry and NRC working group). Interested industry participants may consider forming a working group to develop a list of component failure modes having data aging or sparse data issue, to determine which approaches should be used to address issues such as: Increase data collection efforts? Use expert elicitation for the most important and emergency items? (3) Keep the current status for less important items?

ID	Observation	Basis	Potential Resolutions	Ref	Priority	NRC Response/Resolution
DA5.1	Sensor Failure Rates Based on Old Data: The sensor/transmitter failure rates are based on data from 1984 through 1995 (documented in the NUREG/CR-5500 series). A total of 5.5 Level sensor failures, 37.5 pressure sensor failures, and 46.1 temperature sensor failures were used in the failure rate calculations. The failures were divided into Demand failures and Time-related failures. A number of the failure events are described as "uncertain" based on limited failure event reports. These uncertain events are assigned a weighting factor (less than 1.0).	Generic component failure rates should be based on recent reliability data for each component failure mode. Where recent reliability data are not available, use other techniques (e.g., expert elicitation) to develop appropriate failure rate distributions.	Update the data that supports the sensor/transmitter failure rates. It is expected that failure event reports have improved in level of detail since the data was collected to support the 2015 dataset. Consider collecting recent failure data for one sensor-type (e.g., pressure) and calculate new failure rates (demand, time) with this data. Compare this to the failure rates from the 1984 to 1995-time frame currently in the NRC Dataset (2015). If the failure rates are significantly different, expand the data analysis effort to address the other sensor-types.	PWROG-18029, Appendix A, DA.5	L	***AGREE: FUTURE ACTIVITY PLANNED*** See responses in DA4.1.

Table F-4
PWROG Peer Review Observations and NRC Responses Related to Data Classification

ID	Observation	Basis	Potential Resolutions	Ref	Priority	NRC Response/Resolution
DC1.1	NRC introduces new component failure modes in NRC datasets from 2007, 2010, and 2015. However, it is not clear the justification for including some specific failure modes. In other cases, there may not be adequate data to justify separating out some similar failure modes (e.g., where limited component reliability data has been divided by system). See related observations for component leakage (DC2.1, DC3.1, & DC4.1) and spurious operation (DC5.1 to 5.4).	Component-types should be modeled as separate reliability groups to support the homogeneity of the group but only to the extent sufficient reliability data is available.	Review current component types with limited data to see if grouping similar component types would be a more appropriate balance of homogeneity of the group with the amount of data available. For example, consider motor-driven compressors (PCA-MDC, IAS-MDC, MDC) and engine-driven pumps (AFW-EDP, EDP).	PWROG-18029, Appendix A, DC.1	L	***DISAGREE: NO CHANGES PLANNED*** Over time, NRC has improved the data analysis process including upgrades to failure mode evaluations to help meet stakeholder needs. These changes are reflected in the most recent parameter estimate updates, but they will probably continue to change in the future. In the past, the trend was towards ever increasing detail (and so more system-specific parameters), but the more recent trend has involved pooling some failure modes. NRC will continue its current process to make proper decision on how to better meet various needs.

ID	Observation	Basis	Potential Resolutions	Ref	Priority	NRC Response/Resolution
DC2.1	Leakage Probability: Section A.1.2 of NUREG/CR-6928 discusses the criteria for leakage events from EPIX (1997 to 2004): External leakage events were reviewed to identify small leaks (1 to 50 gpm), large leaks (> 50 gpm), and leaks too small to be of interest in this study (< 1 gpm). Internal leakage events were reviewed to identify small leaks (leaks exceeding the local leak rate test allowable limits or 1 to 50 gpm), large leaks (typically resulting from component internal degradations greater than just pitting or wearing or > 50 gpm), and negligible leaks (less than the local leak rate test limits or < 1 gpm). From this description, it would appear that external leaks may have specified a leakage rate while internal leaks may have only identified "leak exceeds local leak rate test" or "internal degradation" rather than a specific leak rate. The definition of Small Leakage (1 to 50 gpm) is not helpful because it covers the range from nuisance leakage which should not impact system performance to the point where leakage may not be insignificant (depending on the system).	Failure modes in the generic component reliability dataset should include only those associated with internal events hazards. They should not overlap with unique failure modes considered in other hazards.	Redefine Leakage to include only Internal Leakage in the range 10 to 50 gpm. *External* leakage should be classified as an internal flood event and be excluded from this Database (see Observation DC4.1). Leakage any larger than 50 gpm *internal* to the device could be considered a component failure, e.g., manual valve leakage larger than 50 gpm should be counted as Manual Valve Fails to Remain Closed. (See Observation DC3.1.) Internal leakage less than 10 gpm should be considered nuisance leakage which should not impact system performance. Leakage in the range from 10 to 50 gpm is still a challenge to model but should help to focus the concern on leakage events that are more likely to challenge system function over a period of time. Note, the probabilities may be low enough that any internal leakage events could be included in existing component failure modes.	PWROG-18029, Appendix A, DC.2	M	***AGREE: FUTURE ACTIVITY TO BE CONSIDERED*** Items DC2.1, DC3.2, and DC4.1 present observations over the leakage probability, large internal leakage probability, and large external leakage probability. The following potential resolutions have been offered by the PWROG: ▪ Define leakage to include only internal leakage in the range 10 to 50 gpm, ▪ Eliminate large internal leakage as a failure mode, or ▪ Eliminate all external leakage as a failure mode. For the second and third suggestions, NRC does not believe that eliminating the leakage failure mode from the data analysis is appropriate. The data analysis results from NUREG/CR-6928 and subsequent updates are used as inputs to the SPAR models so that it is the PRA modeler's decision on how to utilize the data results and whether or not to include large internal leakage or all external leakage in PRA model. For the first suggestion, while we can check whether changing the threshold value for small leakage from 1 gpm to 10 gpm is proper, we wonder whether or not the benefits from such a redefinition and reclassification of the leakage events are worth the effort as the leakage probabilities are already very small (mostly in the range of E-8 range) compared to the failure probabilities/rates for other failure modes. A joint industry/NRC working group could consider items such as those above to address.

ID	Observation	Basis	Potential Resolutions	Ref	Priority	NRC Response/Resolution
DC3.1	Large Internal Leakage Probability: The value 0.02 is used as the ratio of ILL/ILS (large internal leak failure rate / small) for valves (SRV, SVV, PORV, RVL), tanks (TNK, ACC, STR), and heat exchangers (HTX). This value is documented in Table A.1.2-1 of NUREG/CR-6928 and is based on 3 large internal leaks vs 185.5 small internal leaks (with the ratio rounded off). This data is from the 8-year period from 1997 to 2004. This same ratio (0.02) is used in the 2015 dataset although the data used to calculate ILL failure rate appears to be updated. Thus, this value is based on 3 large leaks from data that is 15 to 20 years old.	Failure modes in the generic component reliability dataset should not be expanded where an existing failure mode can adequately account for the impact of the failure event.	Eliminate large internal leakage as a failure mode in the 2020 reliability dataset. Map these failure modes to existing component failure modes that account for the same impact (e.g., MOV large internal leakage may have the same impact as failure to close). If the 2015 probability estimates of large internal leakage are significant contributors to the mapped component failure modes, update the event data for large internal leakage.	PWROG-18029, Appendix A, DC.3	M	***AGREE: FUTURE ACTIVITY TO BE CONSIDERED*** See responses in DC2.1.
DC4.1	Large External Leakage Probability: The value 0.07 is used as the ratio of ELL/ELS (large external leak failure rate/small) for valves (SRV, SVV, PORV, RVL) and tanks (TNK, ACC, STR). This value is documented in Table A.1.2-1 of NUREG/CR-6928 and is based on 2.0 large external leaks vs 35.0 small external leaks (with the ratio rounded off). This data is from the 8-year period from 1997 to 2004. This same ratio (0.07) is used in the 2015 dataset although the data used to calculate ILL failure rate appears to be updated. Thus, this value is based on 2 large leaks from data that is 15 to 20 years old. Also, this data overlaps with the data used to calculate internal flood frequencies.	Failure modes in the generic component reliability dataset should include only those associated with internal events hazards. They should not overlap with unique failure modes considered in other hazards.	Eliminate all external leakage as a failure mode in the 2020 reliability dataset since this data is (should be) accounted for in the internal flood frequency calculations.	PWROG-18029, Appendix A, DC.3	M	***AGREE: FUTURE ACTIVITY TO BE CONSIDERED*** See responses in DC2.1.

ID	Observation	Basis	Potential Resolutions	Ref	Priority	NRC Response/Resolution
DC5.1	NRC Dataset (2015) identifies events classified as spurious operation for several component types: ▪ PORVs ▪ Safety/Relief valves ▪ Breakers However, failure events that caused a plant transient are initiating events or precursor events rather than (simply) component failures.	The generic component reliability dataset should not include events that cause a plant transient. Those events should be account for in the initiating event analysis.	Remove events from the component reliability dataset where the spurious operation causes a plant transient. These events should be included only in the initiating event dataset. See Appendix E (Slide 18) for a logical classification of spurious operation failure modes and their impacts.	PWROG-18029, Appendix A, DC.5, DC.6, DC.8. Appendix E (Slides 17, 18, 21, 22, 23)	M	***DISAGREE: NO CHANGES PLANNED*** The results from NUREG/CR-6928 and the following updates are used as the inputs to the SPAR models. Unless the associated component failure mode data are no longer needed by SPAR models, such parameter estimates will continue to be provided based on available data.
DC5.2	NRC Dataset (2015) identifies events classified as spurious operation for several component types: ▪ AOVs, ▪ MOVs, ▪ SOVs ▪ Breakers The use of the spurious operation failure mode creates unnecessary complication in system modeling where the impact could be modeled with an existing failure mode (fail to open, fail to close).	Failure modes in the generic component reliability dataset should not be expanded where an existing failure mode can adequately account for the impact of the failure event.	Model failure events included in spurious operation failure modes using other existing failure modes. Eliminate spurious operation as a component failure mode. See Appendix E (Slide 18) for a logical classification of spurious operation failure modes and their impacts.	PWROG-18029, Appendix A, DC.7, DC.8. Appendix E (Slides 17, 18, 19, 23)	M	***DISAGREE: NO CHANGES PLANNED*** Same as DC 5.1.
DC5.3	The term "spurious operation" is used in Fire PRA for a specific fire-induced failure mode. This term should not be used for hardware failures. Spurious operation failure mode is defined using a number of IDs (SOP, SO, SC, OC) and descriptions (spurious operation, spurious opening, spuriously transfers, transfers open, fails to remain open) without any clear distinction on these failure modes.	Failure modes in the generic component reliability dataset should not be expanded where an existing failure mode can adequately account for the impact of the failure event.	Eliminate spurious operation as a component failure mode (see DC5.1). If not eliminated, then clarify the definition and use consistent IDs and descriptions for this failure mode.	PWROG-18029, Appendix A, DC.7; Appendix E (Slides 17, 19)	M	***AGREE: FUTURE ACTIVITY PLANNED*** "Spurious operation" has long been used as a failure mode in nuclear data analysis. As such, there are a number of IDs that use the term, some for historical purposes. The 2020 Update will clarify the various usages of these IDs to be more consistent.

ID	Observation	Basis	Potential Resolutions	Ref	Priority	NRC Response/Resolution
DC5.4	The NRC Dataset (2015) identifies a spurious- operation failure mode for a number of valve types, including AOV-OC/SOP, MOV-OC/SOP, and SOV-SOP. The count of events in the NROD Database was significantly lower than in the NRC Dataset: MOV_SOP events: 63 in NRC Dataset (2015) and 48 in the NROD Database. AOV_SOP events: 132 in NRC Dataset (2015) and 67 in the NROD Database. Spurious operation of SOVs, check valves, and manual valves had counts of 9, 2, and 6 (respectively) in NRC Dataset (2015) but zero events in the NROD Database. Also see Observation DQ2.2.	Documentation of reliability datasets should be consistent with the NROD database.	Resolve the inconsistencies in the 2020 datasets or explain the reasons for potential inconsistencies and how the data should be used (e.g., whether the spreadsheet results should be used when in disagreement with the datasheets).	PWROG-18029, Appendix A, DC.7; Appendix E (Slides 17, 20)	M	***AGREE: FUTURE ACTIVITY PLANNED*** NRC confirmed that there are some inconsistencies between the NROD and RADS. NRC will investigate such discrepancies and make corrections as needed.
DC9.1	The NRC CCF Dataset (2015) provides extremely sparse evidence of common cause failures for spurious operation failure modes: zero events for check valves and DC circuit breakers; one event each for MOVs, AOVs, and 480VAC circuit breakers; and three events for 4160VAC circuit breakers. As discussed in Observations DC5.1, DC5.2 and DC5.3, the evidence for independent spurious operation events is limited and, in many cases, would be better characterized as precursor events. Despite this limited data, CCF parameters are calculated and reported in the NRC CCF Dataset (2015) for spurious operation modes for valves and circuit breakers.	CCF parameters should not be developed for failure modes where both independent and common cause failures are rare events.	Eliminate the spurious operation failure modes from the CCF Dataset based on the limited data for both independent and common cause spurious operation.	PWROG-18029, Appendix A, DC.9	M	***AGREE: FUTURE ACTIVITY PLANNED*** NRC agrees that CCF parameters might not be needed for component failure modes where both the independent and the common cause failures are rare. The 2020 CCF parameter estimate will remove the component failure modes that have no CCF and independent failures. On the other hand, note that the 2015 CCF Parameter Report has a statement in Section 1.2 that asks users to decide what is the appropriate approach for their PRA. The report is meant to be a reference and analysts should decide whether or not to model specific CCF events. Should they decide to do so, the results are there for use.

ID	Observation	Basis	Potential Resolutions	Ref	Priority	NRC Response/Resolution
DC10.1	The failure events recorded in the NROD Database include an assessment of whether the failure was recoverable and an estimate of the recovery duration. However, these failures are treated the same as other failures that may be highly non-recoverable (i.e., with a much longer recovery time). Also see Observations CCF.9 and CCF.10.	Failure events that are highly recoverable (e.g., recoverable within 60 minutes) should be treated as weighted failures to acknowledge that such events have much less risk importance than other failure events.	Consider revising the P_value parameter to include a weighting factor based on the recoverability of the failure event. One possible treatment: Failure events recoverable from the control room within a few minutes without any significant troubleshooting (e.g., control switch in pull-to-lock): P_value = 0.1 Failure events recoverable within 15 minutes without any significant troubleshooting (e.g., resetting the turbine- driven AFW pump trip/throttle valve): P_value = 0.2 Failure events recoverable within 60 minutes without any significant troubleshooting (e.g., resetting a pump breaker): P_value = 0.5	PWROG-18029, Appendix A, DC.9; Appendix C (Slide 17)	M	***DISAGREE: NO CHANGES PLANNED*** While the thought of revising P_value with weighting factors based on the recoverability of the failure event appears interesting, NRC does not believe it is a good idea to mix or combine failure probability and recovery probability. NRC believes that recoverability should be treated separately, at least that has been common PRA practice. Implementation of such an approach also has the drawback that it would require wholesale reclassification of thousands of failure records for new P_values.

Table DQ 1-1
Pairs of Duplicate Entries with Different IDs with NRC Review Results

ID	Failures	Demands/Hours	Components	NRC Response
TBV-FTO	8	2,725	73	Not duplicates: these are two different failure modes, fail-to-open and fail-to-open/close, both having 8 failures.
TBV-FTOC	8	2,725	73	
SVV-FTC-PWR-RCS	1	2,907	155	Not duplicates: there was 1 fail-to-close event (Point Beach 1, 2004) and 1 fail-to-close event (Indian Point 2, 2006) of RCS SVVs.
SVV-FTO-PWR-RCS	1	2,907	155	
PLF FTOP	3	6,075	*	Not duplicates: the 2015 Update has a comment “The PLL data was used to estimate the flow process logic (PLF) reliability.”
PLL FTOP	3	6,075	*	
PORV-FTO-PPR	16	6,130	114	Duplicates corrected: these two templates are redundant. Redundant entry was removed from the 2020 Update.
PRV-CC-PZR	16	6,130	114	
STF FTOP-D	5	6,750	*	Not duplicates: the 2015 Update has a comment “The STL data was used to estimate the flow sensor/transmitter (STF) reliability.”
STL FTOP-D	5	6,750	*	
ARV-OO-MSS	19	10,401	111	Duplicates corrected: these two templates are redundant. ARV- is used in SPAR models while PORV- is used in data collection and analysis. Redundant entry was removed from the 2020 Update.
PORV-FTC-MSS	19	10,401	111	
ARV-CC-MSS	42	10,401	111	Duplicates corrected: similar with the above, Redundant entry (ARV-CC-MSS) was removed from the 2020 Update.
PORV-FTO-MSS	42	10,401	111	
ACX-FTS	45	17,336	139	Duplicates corrected: these two templates are redundant. ACX- is used in SPAR models while AHU- was used in NUREG/CR-6928 and the 2015 Update. Redundant entry (AHU-NR-FTS as well as AHU-NR-FTR) were removed from the 2020 Update.
AHU-NR-FTS	45	17,336	139	
IAS-FLT-FC	0	122,688	2	Not duplicates but removed: these are for two different failure modes, fail-to-operate (FC) and Plug (PG), both having 0 failure. But since IAS-FLT-PG is the only one used in SPAR models, IAS-FLT-FC was removed from the 2020 Update spreadsheet.
IAS-FLT-PG	0	122,688	2	
CHL-FTR<1H	61	279,348	63	Not duplicates: chiller has only FTR failure mode in RADS. So FTR<1H and FTR>1H use the same data to achieve the same failure rate. A comment was added to the 2020 Update to explain the situation.
CHL-FTR>1H	61	279,348	63	
MDC-FTR<1H	22	1,683,943	58	Duplicates corrected: the MDC-FTR<1H values in the 2015 Update were incorrect. The 2020 Update will show correct values.
MDC-FTR>1H	22	1,683,943	58	
SWS-TSA-PG	0	2,331,600	15	Not duplicates but removed: these are two different templates with the -NE one for non-environment failure causes. But since TSA-PG-NE-SWS is the only one used in SPAR models, SWS-TSA-PG was removed from the 2020 Update spreadsheet.
TSA-PG-NE-SWS	0	2,331,600	15	
TDP-FR-NR-MFW	62	5,984,882	43	Data error corrected: (1) The TDP-FS-NR-MFW values in the 2015 Update were incorrect. (2) TDP-NR-FTR has the same values as TDP-FR-NR-MFW since normally running TDPs are from MFW only. Since TDP-FR-NR-MFW is the one used in SPAR models, TDP-NR-FTR was removed from the 2020 Update.
TDP-FS-NR-MFW	62	5,984,882	43	
TDP-NR-FTR	62	5,984,882	43	
STF FTOP-R	0	9,831,970	*	Not duplicates: the 2015 Update has a comment “The STL data was used to estimate the flow sensor/transmitter (STF) reliability.”
STL FTOP-R	0	9,831,970	*	
TSA-FR	97	30,417,290	212	Data error corrected: TSA-FS and TSA-FR were added to the 2015 Update using the same data of TSA-FTOP, which may not be appropriate. TSA-FS and TSA-FR were removed from the 2020 Update.
TSA-FS	97	30,417,290	212	
TSA-FTOP	97	30,417,290	212	
HTX-CCW-LOHT	17	34,265,020	227	Duplicates corrected: these two templates are redundant. -PG is used in SPAR models while -LOHT is used in data collection and analysis. Redundant entry was removed from the 2019 Update.
HTX-PG-CCW	17	34,265,020	227	
PORV-FC	13	49,398,360	317	Duplicates corrected: PORV-FC is a redundant template in the 2015 Update. It was removed from the 2020

ID	Failures	Demands/Hours	Components	NRC Response
PORV-FC-MSS	13	49,398,360	317	Update.
SRV-ELS	0	72,220,220	558	Not duplicates: there was 0 SRV external leakage small (ELS) event and 0 fails-to-control event (FC).
SRV-FC	0	72,220,220	558	
ROD-FTOP	20	132,832,800	846	Not duplicates: these are for two different failure modes, control rod fails-to-operate (FTOP) and control rod spurious operation (SOP). It was a coincidence that there were 20 FTOP events (5 from Columbia, 3 from SLC2, 2 from Oconee 1, etc.) and 20 SOP events (7 from SLC1, 8 from SLC2, and 1 each for other plants).
ROD-SOP	20	132,832,800	846	

Notes:
* These entries are blank in the NRC Dataset (2015).

Table DQ 1-2
Miscellaneous Issues on 2015 NRC Dataset with NRC Review Results

Component Failure Mode	Description	Data Source	Failures	Demands/ Hours	d/h	Components	Mean	EF	Date Range	Data Issue	NRC Response
AFW-EDP-FTR<1H	AFW Engine-driven pump Fails to Run <1H	EPIX/RADS	4	739	h	5	6.09E-3	2.0	1998–2015	Limited Data (<1000 hrs)	The data and estimation are appropriate
AFW-EDP-FTR>1H	AFW Engine-driven pump Fails to Run >1H	EPIX/RADS	2	262	h	5	9.53E-3	2.5	1998–2015	Limited run-hours do not justify separate data parameters for Early Term and Late Term.	
AOV-FTC	Air Operated Valve Fails to Close	EPIX/RADS	53	201,147	d	1767	3.63E-4	7.6	1998–2015	Questionable # of demands (same as AOV-FTOC)	Not an error even though FTC, FTO, and FTOC have the same demands.
AOV-FTO	Air Operated Valve Fails to Open	EPIX/RADS	78	201,147	d	1767	3.91E-4	5.2	1998–2015	Questionable # of demands (same as AOV-FTOC)	
CRB-CO-480	Low Voltage (480V) Circuit Breaker Spurious Operation	EPIX/RADS	39	396,295,000	h	2629	9.97E-8	1.3	1998–2015	ID should be CBK-xxx to be consistent with other circuit breakers	CRB- was changed to CBK- in the 2020 Update.
CRB-FTOC-480	Low Voltage (480V) Circuit Breaker Fails to Open/Close	EPIX/RADS	56	55,060	d	1776	1.03E-3	1.2	1998–2015	ID should be CBK-xxx to be consistent with other circuit breakers	
CSW-MDP-FR	CSW Motor Driven Pump Fails to Run	EPIX/RADS	25	3,654,539	h	32	6.98E-6	1.4	1998–2015	Data variable and description should be CWS (circ water system) rather than CSW per Table 2-2 of Datasheets.	Data Correction: CSW was changed to CWS in the 2020 Update.
CTG-FTR	Gas Turbine Generator Fails to Run, Late Term	EPIX/RADS	5	648	h	2	8.49E-3	1.9	1998–2015	Limited run-hours do not justify separate data parameters for Early Term and Late Term.	The data and estimation are appropriate.

Component Failure Mode	Description	Data Source	Failures	Demands/ Hours	d/h	Components	Mean	EF	Date Range	Data Issue	NRC Response
HCU-FTI	Hydraulic Control Unit Fails to Insert	EPIX/RADS	0	—	d	0	—		1998–2015	No Failure Rate	Data Correction: The data source should be the RPS System Study with a mean value of 1.10E-7; corrected in the 2020 Update.
MCC-FTOP	Motor Control Center Fail to Operate	EPIX/RADS	6	34,080,880	h	217	1.91E-7	1.8	1998–2015	The end of the Date Range (2018) is inconsistent with the rest of the data (2015) and appears to be in error.	Data Correction: Typo in the 2015 Update; should be 2015 not 2018.
MDC-FTR>1H	Motor Driven Compressor Fail to Run (> 1 Hour)	EPIX/RADS	22	1,683,943	h	58	1.34E-5	1.4	1998–2015	It appears that the data (successes, failures) for MDC-FTR<1H were used here.	Data Correction: The MDC-FTR<1H values in the 2015 Update were incorrect. The 2020 Update will show correct values.
MDP-CCW-FTS	CCW Motor-driven pump Fail to Start	EPIX/RADS	69	88,693	h	291	8.78E-4	4.0	1998–2015	Labeled FTS, but "h" (per hour)	Data Correction: Typo in the 2015 Update; 2020 Update will show correct values.
MDP-SBY-FTR>1H	Motor-Driven Pump Fails to Run, Late Term	EPIX/RADS	143	20,062,180	h	1311	1.15E-5	6.5	1998–2015	# of run-hours seems to be too high for standby pump (based on RunHrs per pump per yr)	No issue: There were 482,286 demands over the time. The ratio of run-hrs/demands is about 40 hrs/demand, which is in the normal area for a standby pump.
MOD-ILS	Motor Operated Damper Internal Leakage (Small)	EPIX/RADS	1	17,147,900	d	111	8.75E-8	3.3	1998–2015	Questionable # of demands	No issue: The run-hours for leakage is based on calendar year ("d" should be "h"). 17.1 million hours for 111 components in 18 years (average 8583 run-hours/component/yr) look good.
MOV-FTC	Motor Operated Valve Fail to Close	EPIX/RADS	234	740,890	d	6902	3.35E-4	3.0	1998–2015	Questionable # of demands (same as MOV-FTOC)	No issue that FTC, FTO, and FTOC have the same demands.
MOV-FTC-BFV	Butterfly Valve Fail to Close	EPIX/RADS	34	109,522	d	961	3.38E-4	4.0	1998–2015	Questionable # of demands (same as MOV-FTOC)	

Component Failure Mode	Description	Data Source	Failures	Demands/ Hours	d/h	Component s	Mean	EF	Date Range	Data Issue	NRC Response
MOV-FTO	Motor Operated Valve Fail to Open	EPIX/RADS	293	740,890	d	6902	4.21E-4	2.3	1998–2015	Questionable # of demands (same as MOV-FTOC)	
MOV-FTO-BFV	Butterfly Valve Fail to Open	EPIX/RADS	27	109,522	d	961	2.51E-4	1.3	1998–2015	Questionable # of demands (same as MOV-FTOC)	
NSW-MDP-FR	Nuclear Service Water MDP Fails to Run	EPIX/RADS	64	10,256,170	h	104	6.72E-6	4.0	1998–2015	This variable is named SWN (normally operating SW) in the data sheets (Table 2- 2). Also, this data set has 104 components compared to MDP-SWS-FTR which has 106. It is not clear what the difference is between these two groups.	NSW-MDP-FR and MDP-SWS-FTR have different criteria with NSW for normally operating SW only and SWS for both normally operating SW and standby SW. However, both use failure mode of Fail to Run, which is rarely used in standby systems (which mostly use FTR<1H and FTR>1H). The 2020 Update addressed the issue by clarifying whether a template is for normally operating SW only or for all SW.
PDP-SBY-FTR>1H	Positive Displacement Pump Fails to Run, Late Term	EPIX/RADS	2	1,710	h	72	1.46E-3	2.5	1998–2015	Limited run-hours do not justify separate data parameters for Early Term and Late Term.	The data and estimation are appropriate.
PLDTFTOP	Process Logic (Delta Temperature) Fail to Operate	RPS SSs	24	4,887	d	—	5.07E-3	8.4		Documentation error. The Comment says, "The PLL data was used to estimate the flow process logic reliability." It should not refer to flow devices.	Data Correction: the comment should be removed.

Component Failure Mode	Description	Data Source	Failures	Demands/ Hours	d/h	Components	Mean	EF	Date Range	Data Issue	NRC Response
PMP-Volute	Pump Volute Fails to Run (Driver Independent Centrifugal Pumps)	EPIX/RADS	25	158,885	h	207	1.60E-4	1.4	1998–2015	# of run-hours seems to be too high compared to other MDP-SBY based on RunHrs per pump per yr)	There were about 54,000 demands over the time. The ratio of run-hrs/demands is about 3 hrs/demand, which is actually on the lower side of normal for standby pumps.
PORV-FC	Main Steam Power Operated Relief Fails to Control (Cooldown)	EPIX/RADS	13	49,398,360	d	317	2.57E-7	10.0	1998–2015	Questionable # of demands	Data Correction: per demand should be per hour
PORV-FC-MSS	Main Steam Power Operated Relief Fails to Control (Cooldown)	EPIX/RADS	13	49,398,360	d	317	2.57E-7	10.0	1998–2015	Questionable # of demands	
PORV-L	PORVs/SRVs Open During LOOP	Special Calculation			d	0	1.48E-1			Data Source should use reference: NUREG/CR-7037 Table 13	The special calculation refers to NUREG/CR-7037, Relief Valve Study
PORV-Liquid	PORVs Fail to Close After Passing Liquid	Special Calculation	0	7	d	0	6.25E-2	10.3		Data Source should use reference: NUREG/CR-7037 Table 30	
PORV-P1	PWR One PORV/SRV Sticks Open	Special Calculation	18	13,897	d	0	1.46E-3	2.8		Data Source should use reference: NUREG/CR-7037 Table 30	The special calculation refers to NUREG/CR-7037.
PORV-T	PORVs/SRVs Open During Transient	Special Calculation			d	0	3.55E-2			Data Source should use reference: NUREG/CR-7037 Table 13	
ROD-FTOP	Control Rod Fails to Operate/Insert Rod	EPIX/RADS	20	132,832,800	d	846	1.54E-7	1.4	1998–2015	Questionable EF [(b)]	Parameter estimate uncertainty would be a special issue to address.

Component Failure Mode	Description	Data Source	Failures	Demands/ Hours	d/h	Component s	Mean	EF	Date Range	Data Issue	NRC Response
STTFTOP-D	Sensor/Transmitter (Temperature) Fail to Operate on Demand	RPS SSs	17	40,759	d	---	4.32E-4	8.4		Documentation error. The Comment says, "The STL data was used to estimate the flow sensor/transmitter reliability." It should not refer to flow devices.	Yes, this was an error. The comment should be removed.
SWS-MDP-FS-NE	SWS Pump Non-Enviro- FTS	EPIX/RADS	149	249,957	h	446	7.55E-4	3.8	1998–2015	Labeled FTS, but "h" (per hour)	Yes, it should be "d"
TBV-FTC	Turbine Bypass Valve Fails to Close	EPIX/RADS	0	2,725	d	73	1.83E-4	8.4	1998–2015	Questionable # of demands (same as TBV-FTOC)	No issue that FTC, FTO, and FTOC have the same demands.
TBV-FTO	Turbine Bypass Valve Fail to Open	EPIX/RADS	8	2,725	d	73	3.12E-3	1.7	1998–2015	Questionable # of demands (same as TBV-FTOC)	
TDP-FR-L-HCI-RCI	HCI-RCI Turbine Driven Pump Fails to Run, Late Term	EPIX/RADS	10	1,922	h	59	5.52E-3	2.8	1998–2015	Limited run-hours do not justify separate data parameters for Early Term and Late Term.	The data and estimation are fine.
TDP-FS-NR-MFW	MFW Turbine Driven Pump Fails to Start, Normally Running	EPIX/RADS	62	5,984,882	d	43	1.09E-5	3.2	1998–2015	# of demands seems to be too high (based on demands per pump per yr)	This was a copy and paste error (using the FTR data) in the spreadsheet. The 2015 Data Sheet shows the correct number of 12 failures in 1,395 demands.
TNK-FC	Tank Rupture	EPIX/RADS	15	59,350,270	h	379	2.61E-7	1.5	1998–2015	The end of the Date Range (2018) is inconsistent with the rest of the data (2015) and appears to be in error.	Yes, this is a typo in the 2015 Update.
TSA-FS	Traveling Screen Fails to Start	EPIX/RADS	97	30,417,290	d	212	3.67E-6	6.9	1998–2015	Questionable # of demands	TSA-FS was added to the 2015 Update using the same data of TSA-FTOP, which may not be appropriate. TSA-FS was removed from the 2020 Update.

Component Failure Mode	Description	Data Source	Failures	Demands/ Hours	d/h	Component s	Mean	EF	Date Range	Data Issue	NRC Response
VBV-FTC	Vacuum breaker fails to close	EPIX/RADS	6	27,842	d	167	2.15E-4	5.7	1998–2015	Questionable # of demands (same as VBV-FTOC)	No issue that FTC, FTO, and FTOC have the same demands.
VBV-FTO	Vacuum Breaker Valve Fail to Open	EPIX/RADS	2	27,842	d	167	8.98E-5	.5	1998–2015	Questionable # of demands (same as VBV-FTOC)	