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Component Reliability Data Issues for Continued Discussion with NRC

Based on Report PWROG-18029-NP and Project PA-RMSC-1494

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Introduction

Purpose of project PA-RMSC-1494 and report PWROG-18029

- Provide a strong basis for engaging with the NRC to improve the generic component reliability data sources.
- Support the long-term needs of the nuclear power industry for high quality generic component reliability estimates for utility PRAs.

Objective of the interaction with NRC

- Ensure that the data issues in PWROG-18029 are understood by the NRC and INL staff.
- Support efforts to address these data issues in the next NRC reliability data sets (2020).

Objective of this meeting

- Continue discussion of key technical issues
- Expansion of several technical areas
- Identify potential options to address these issues

Priorities for Discussion

A. Common Cause Failure Issues

1. DQ.8, CCF Weighting Factors & Mapping-Up Process
2. DA.2, Time Trends of CCF Events
3. Reassessment of CCF Events *

B. Component Failure Rate Issues

1. DA.1, Time Trends of Component Failure Events
2. DQ.5, Long-term Failure Rates *
3. DC.10, Treatment of Highly-Recoverable Failures
4. DA.4, Failure Rate for Safety Valve Fail-to-Reclose

C. Miscellaneous Data Issues

1. DC.2 to 4, Component Leakage Modeling
2. DC.5 to 9, Spurious Operation Failure Modes
3. DQ.7, Basis for Error Factors

**Expansion of technical issues*

A. Common Cause Failure Issues

1. DQ.8, CCF Weighting Factors & Mapping-Up Process
2. DA.2, Time Trends of CCF Events
3. Reassessment of CCF Events

A. Common Cause Failure Issues

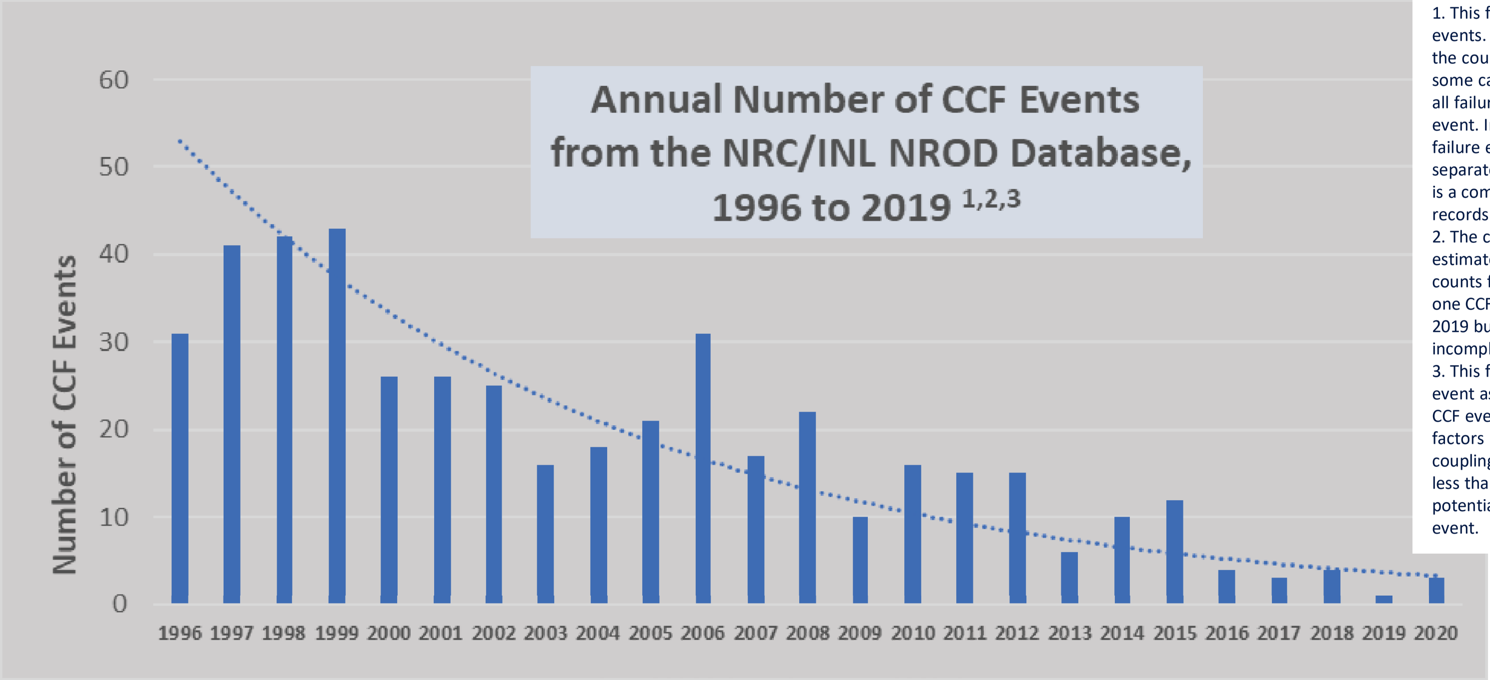
#DQ.8: CCF Weighting Factors & Mapping-Up Process

- The process used in characterizing CCF events to calculate CCF parameters (weighting factors and mapping-up factors) is critical to understanding the basis for these CCF parameters.
- Specifically:
  - How weighting factors (P_values, coupling strength, time factor, failure mode applicability) are used to calculate CCF parameters;
  - How CCF events of size N are used to calculate CCF parameters for CCCGs of size N+1 or more (mapping up) for lethal and non-lethal shock; and
  - How prior distributions are developed and how the priors influence parameters, especially where there is limited data.
- Suggestions:
  - These factors and their bases should be clearly documented so that the process is understandable to other data analysts.
  - Once these are available for review, we will review the process in greater detail and perhaps offer additional comments.

A. Common Cause Failure Issues

#DA.2: 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.
- Suggestion: use the most recent set of events to calculate generic CCF parameters.



Notes:
1. This figure is the count of CCF events. This is not the same as the count of CCF records. In some cases, one record includes all failure events within the CCF event. In other cases, each failure event is included as a separate record; the CCF event is a combination of these event records.
2. The count for 2020 is an estimate based on the average counts from 2016 to 2019. Also, one CCF event was reported for 2019 but that data may be incomplete at this time.
3. This figure counts each CCF event as one. In a number of CCF events, the weighting factors (e.g., time delay, coupling strength, P-Value) were less than 1.0, indicating a potential (but not actual) CCF event.

A. Common Cause Failure Issues

Reassessment of CCF Events

See Attachment 1

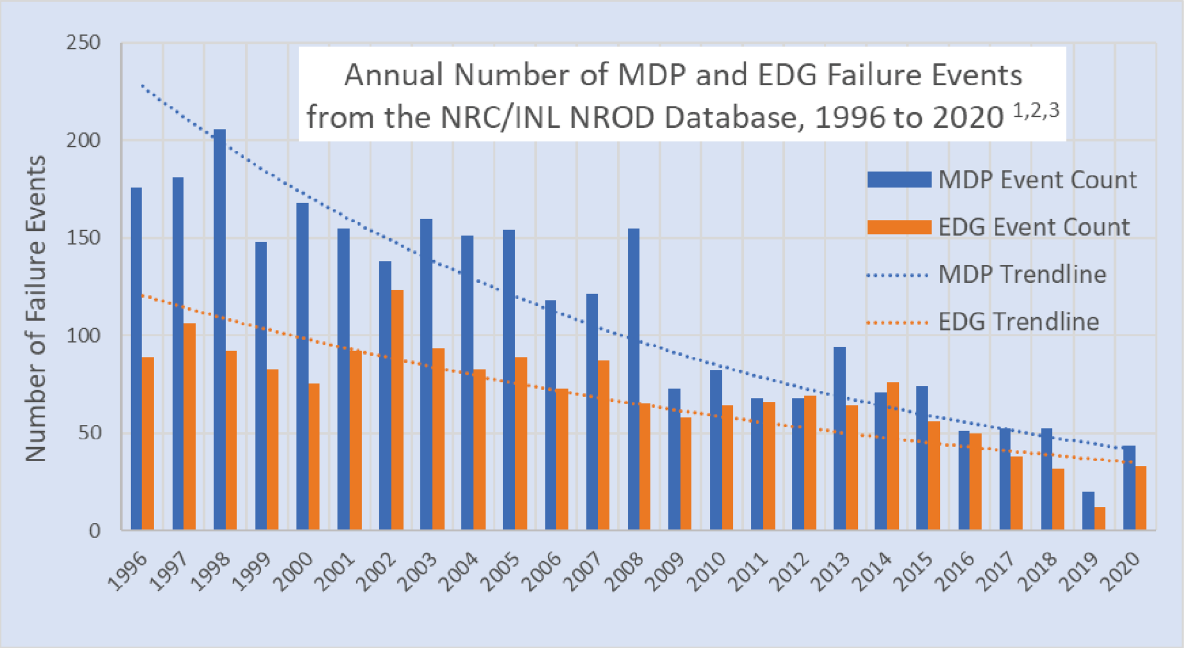
B. Component Failure Rate Issues

1. DA.1, Time Trends of Component Failure Events
2. DQ.5, Long-term Failure Rates
3. DC.10, Treatment of Highly-Recoverable Failures
4. DA.4, Failure Rate for Safety Valve Fail-to-Reclose

B. Component Failure Rate Issues

DA.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.
- Suggestion: use the most recent set of events to calculate generic failure rates. These datasets should be consistent with CCF parameter calculations (see Issue #DA.2).



Notes:
1. An estimate of counts for 1996 (using the average for 1997 to 2000) was used since the failures in the NROD database are incomplete prior to 1997.
2. An estimate for 2020 (using the average for 2016 to 2019) was included since the NROD database does not yet include any 2020 data. Also, some 2019 failure events have been reported but that data may be incomplete at this time.
3. This figure counts each component failure event as one. In a number of failure events, the P_Value weighting factor was less than 1.0, indicating a potential (but not actual) failure event. In addition, several failures were identified as recoverable in the short term. Neither of these factors are included in the count.

B. Component Failure Rate Issues

DQ.5: Long-term Failure Rates

This issue relates to the short term (first hour) failure rate data compared with the long term (beyond first hour) failure rate data.

Specific Items from NRC Dataset 2015, with suggestions:

1. Review/ revise pooled data for MDP-SBY-FTR>1H
    - The run-hours data are much too long (2.01E7 hrs). With 4.82E5 starts, this implies 40 hrs per start. Does this pooled data include RHR pumps (which are standby during plant operation but normally running during plant shutdown)?
2. Combine Short Term and Long Term run data for STBY components:
    - Limited long-term run data for standby components. Test runs are typically no longer than 1 hour
    - Difficult to determine whether failure events are actually Short Term or Long Term
    - For most cases, Long Term failure rates are not lower than Short Term, as one might expect.
3. Revise EDG FTLR and FTR calculations

B. Component Failure Rate Issues

DQ.5: Long-term Failure Rates

Combine Short Term and Long Term run data for STBY components based on difficulty to determine whether failure events are actually Short Term or Long Term.

- Example, an EDG failure event (7/16/2008) labeled as a FTLR:

  EDG2-2 was running unloaded during the performance of the monthly surveillance test when a lube oil leak from a four inch piping coupling was identified by local operators. The lube oil leak was observed approximately 10 minutes into the run of the engine. The lube oil leakage was initially documented as 224 drops per minute and increased to a steady 'pencil stream' along with a second intermittent stream outside the downstream follower. These streams were observed for approximately 2 minutes before EDG2-2 was shut down and declared inoperable.

- This is determined to be a failure due to the large rate of lube oil leakage. However, is it appropriate to consider this a "one-hour-run-failure" just because it occurred in the first few minutes of this test run?
  - While the event description does not provide details regarding why the leak occurred, it is likely that it was the result of high cycle fatigue failure where the wear-cycles occurred over a number of run-hours.
  - It is likely that the leak was due to the aggregate number of EDG run-hours which accumulated over a number of one-hour test runs but could have occurred during an extended EDG run given a real demand.

B. Component Failure Rate Issues

DQ.5: Long-term Failure Rates

Component Failure Mode	Description	# Failures	Demands or Run-Hours	d or h	# Compnts	PointEst	Mean	Pt.Est. Ratio (E+L)/L	Comments
MDP-SBY-FTS	Motor Driven Pump Fails To Start, Normally Standby	351	482,206	d	1311	7.28E-04	7.94E-04		Combine early & late, small increase in FTR compared to FTR>1HR due to the overwhelming evidence is in the late-term. However, Late term run hours (2.0E7 hrs) seems extremely large for standby pumps. That implies 41 hrs per start.
MDP-SBY-FTR<1H	Motor Driven Pump Fails To Run, Early Term	48	437,647	h	1311	1.10E-04	1.22E-04		
MDP-SBY-FTR>1H	Motor Driven Pump Fails To Run, Late Term	143	20,062,180	h	1311	7.13E-06	1.15E-05		
FTR	Early + Late Fail to Run	191	20,499,827			9.32E-06		1.31	
TDP-SBY-FTS	Turbine Driven Pump Fails To Start (Pooled Systems), Normally Standby	146	26,558	d	133	5.50E-03	6.01E-03		Combine early & late due to limited evidence in the late-term, small increase in FTR compared to FTR>1HR.
TDP-SBY-FTR<1H	Turbine Driven Pump Fails To Run (Pooled Systems), Early Term	61	18,025	h	133	3.38E-03	3.70E-03		
TDP-SBY-FTR>1H	Turbine Driven Pump Fails To Run (Pooled Systems), Late Term	23	11,205	h	133	2.05E-03	2.10E-03		
FTR	Early + Late Fail to Run	84	29,230			2.87E-03		1.40	
TDP-FS-NS-AFW	AFW Turbine Driven Pump Fails To Start, Normally Standby	72	18,054	d	74	3.99E-03	4.33E-03		Combine early & late due to limited evidence in the late-term.
TDP-FR-E-AFW	AFW Turbine Driven Pump Fails To Run, Early Term	40	12,076	h	74	3.31E-03	3.67E-03		
TDP-FR-L-AFW	AFW Turbine Driven Pump Fails To Run, Late Term	13	9,283	h	74	1.40E-03	1.45E-03		
FTR	Early + Late Fail to Run	53	21,358			2.48E-03		1.77	

B. Component Failure Rate Issues

DQ.5: Long-term Failure Rates

Component Failure Mode	Description	# Failures	Demands or Run-Hours	d or h	# Compnts	PointEst	Mean	Pt.Est. Ratio (E+L)/L	Comments
TDP-FS-NS-HCI-RCI	HCI-RCI Turbine Driven Pump Fails To Start, Normally Standby	41	4,929	d	31	8.32E-03	8.78E-03		Combine early & late due to limited evidence in the late-term
TDP-FR-E-HCI-RCI	HCI Turbine Driven Pump Fails To Run, Early Term	21	5,949	h	59	3.53E-03	3.75E-03		
TDP-FR-L-HCI-RCI	HCI-RCI Turbine Driven Pump Fails To Run, Late Term	10	1,922	h	59	5.20E-03	5.52E-03		
FTR	Early + Late Fail to Run	31	7,871			3.94E-03		0.76	
EDP-FTS	Engine Driven Pump Fails To Start, Normally Standby	26	17,988	d	37	1.45E-03	2.17E-03		Combine early & late due to limited evidence in the late-term
EDP-FTR<1H	Engine Driven Pump Fails To Run, Early Term, Normally Standby	10	10,717	h	37	9.33E-04	9.80E-04		
EDP-FTR>1H	Engine Driven Pump Fails To Run, Late Term, Normally Standby	11	5,820	h	37	1.89E-03	1.98E-03		
FTR	Early + Late Fail to Run	21	16,537			1.27E-03		0.67	
AFW-EDP-FTS	AFW Engine-driven pump Fails to Start	3	1,275	d	5	2.35E-03	2.74E-03		Combine early & late due to limited evidence in the late-term
AFW-EDP-FTR<1H	AFW Engine-driven pump Fails to Run <1H	4	739	h	5	5.41E-03	6.09E-03		
AFW-EDP-FTR>1H	AFW Engine-driven pump Fails to Run >1H	2	262	h	5	7.62E-03	9.53E-03		
FTR	Early + Late Fail to Run	6	1,002			5.99E-03		0.79	
PDP-SBY-FTS	Positive Displacement Pump Fails To Start, Normally Standby	16	10,799	d	72	1.48E-03	1.53E-03		Combine early & late due to limited evidence in the late-term
PDP-SBY-FTR<1H	Positive Displacement Pump Fails To Run, Early Term	2	4,699	h	72	4.26E-04	5.32E-04		
PDP-SBY-FTR>1H	Positive Displacement Pump Fails To Run, Late Term	2	1,710	h	72	1.17E-03	1.46E-03		
FTR	Early + Late Fail to Run	4	6,409			6.24E-04		0.53	

B. Component Failure Rate Issues

DQ.5: Long-term Failure Rates

Component Failure Mode	Description	# Failures	Demands or Run-Hours	d or h	# Compnts	PointEst	Mean	Pt.Est. Ratio (E+L)/L	Comments
ACX-FTS-NS	Air Cooling Heat Exchanger Fails to Start, Normally Standby	55	149,242	d	382	3.69E-04	5.57E-04		Combine early & late due to overwhelming evidence in the late-term
ACX-FTR<1H	Air Cooling Heat Exchanger Fails to Run <1H Normally Standby	0	148,103	h	382	0.00E+00	3.38E-06		
ACX-FTR>1H	Air Cooling Heat Exchanger Fails to Run >1H Normally Standby	45	10,793,680	h	382	4.17E-06	4.22E-06		
FTR	Early + Late Fail to Run	45	10,941,783			4.11E-06		0.99	
CHL-FTS-NS	Chiller Unit Fails To Start, Normally Standby	0	20,433	d	63	0.00E+00	2.45E-05		Results are suspect (early and late entries are exactly the same). If this is correct, combine early and late since evidence is the same.
CHL-FTR<1H	Chiller Unit Fails To Run <1H, Normally Standby	61	279,348	h	63	2.18E-04	2.20E-04		
CHL-FTR>1H	Chiller Unit Fails To Run >1H, Normally Standby	61	279,348	h	63	2.18E-04	2.20E-04		
FTR	Early + Late Fail to Run	122	558,697			2.18E-04		1.00	
FAN-SBY-FTS	HVAC Fan Fails To Start, Normally Standby	37	57,512	d	130	6.43E-04	6.52E-04		Combine early & late due to overwhelming evidence in the late-term
FAN-SBY-FTR<1H	HVAC Fan Fails To Run, Early Term, Normally Standby	16	43,744	h	130	3.66E-04	3.77E-04		
FAN-SBY-FTR>1H	HVAC Fan Fails To Run, Late Term, Normally Standby	27	137,892	h	130	1.96E-04	1.99E-04		
FTR	Early + Late Fail to Run	43	181,636			2.37E-04		1.21	
MDC-FTS-NS	Motor Driven Compressor Fail To Start, Normally Standby	61	23,363	d	58	2.61E-03	4.16E-03		Results are suspect (early and late entries are exactly the same). If this is correct, combine early and late since evidence is the same.
MDC-FTR<1H	Motor Driven Compressor Fail To Run (0 To 1 Hour)	22	1,683,943	h	58	1.31E-05	1.34E-05		
MDC-FTR>1H	Motor Driven Compressor Fail To Run (> 1 Hour)	22	1,683,943	h	58	1.31E-05	1.34E-05		
FTR	Early + Late Fail to Run	44	3,367,886			1.31E-05		1.00	

B. Component Failure Rate Issues

DQ.5: Long-term Failure Rates

Component Failure Mode	Description	# Failures	Demands or Run-Hours	d or h	# Compnts	PointEst	Mean	Pt.Est. Ratio (E+L)/L	Comments
EDC-FS-NS	Engine Driven Compressor Fails To Start, Normally Standby	17	2,122	d	5	8.01E-03	8.24E-03		Combine early & late due to limited run-hour evidence
EDC-FR-E	Engine Driven Compressor Fails To Run <1H, Normally Standby	0	2,122	h	5	0.00E+00	2.36E-04		
EDC-FR-L	Engine Driven Compressor Fails To Run >1H, Normally Standby	0	1,735	h	5	0.00E+00	2.88E-04		
FTR	Early + Late Fail to Run	0	3,857			0.00E+00		n/a	
CTF-STBY-FTS	Cooling Tower Fan Fails To Start (Standby)	16	44,600	d	54	3.59E-04	3.70E-04		Combine early & late due to overwhelming evidence in the late-term
CTF-STBY-FTR<1H	Cooling Tower Fan Fails To Run <1H (Standby)	0	44,488	h	54	0.00E+00	1.12E-05		
CTF-STBY-FTR>1H	Cooling Tower Fan Fails To Run >1H (Standby)	2	1,073,115	h	54	1.86E-06	2.33E-06		
FTR	Early + Late Fail to Run	2	1,117,603			1.79E-06		0.96	
HTG-FTS	Hydro Electric Turbine Generator Fails To Start	11	7,270	d	2	1.51E-03	1.58E-03		The evidence may be sufficient to justify a different early vs late failure rate due to unique nature of this component.
HTG-FTLR	Hydro Electric Turbine Generator Fail To Run (< 1 Hour)	7	4,629	h	2	1.51E-03	1.62E-03		
HTG-FTR	Hydro Electric Turbine Generator Fail To Run (> 1 Hour)	1	10,678	h	2	9.36E-05	1.40E-04		
FTR	Early + Late Fail to Run	8	15,307			5.23E-04		5.58	
CTG-FTS	Gas Turbine Generator Fails To Start, Normally Standby	18	503	d	3	3.58E-02	5.12E-02		Combine early & late due to limited run-hour evidence
CTG-FTLR	Gas Turbine Generator Fails To Load And Run, Early Term	2	432	d	2	4.63E-03	5.79E-03		
CTG-FTR	Gas Turbine Generator Fails To Run, Late Term	5	648	h	2	7.72E-03	8.49E-03		
FTR	Early + Late Fail to Run	7	1,080			6.48E-03		0.84	

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B. Component Failure Rate Issues

DQ.5: Long-term Failure Rates

Specific Suggestion for EDG Failure Rate Calculations

1. 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.
2. Define FTLR (FTL) as demand-failure.
3. Review FTLR failure events using new definition of FTL. Move any run-failure events to calculation of FTR.
4. Calculate FTR using all Run-Failure events and all Run-Hours

EDG Failure Mode	Description	# Failures	Demands or Run-Hours	d or h	PointEst	Comments
EDG-FTS	Diesel Generator Fails To Start	214	75,452	d	2.84E-03	Revised calculation for FTL and FTR assumes half of FTLR are load-failures and half run-failures.
EDG-FTLR	Diesel Generator Fails To Load & Run, Early	239	65,993	h	3.62E-03	
EDG-FTR	Diesel Generator Fails To Run, Late Term	184	133,976	h	1.37E-03	
EDG-FTL	Diesel Generator Fails to Load	120	65,993	d	1.82E-03	
EDG-FTR	Diesel Generator Fails To Run	303	199,969	h	1.52E-03	

B. Component Failure Rate Issues

DC.10: Treatment of Highly Recoverable Failures

Documentation of failure events in the NROD Database includes an assessment of whether the failure was recoverable and an estimate of the recovery duration.

- Highly recoverable failures are treated the same as other failures that may be non-recoverable (i.e., with a much longer recovery time).
- Failure events that are highly recoverable (e.g., recoverable within ~60 min) should be treated as weighted failures to acknowledge that such events have much less risk importance than other failure events.

Suggestion:

The definition of P_value could be revised 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 trouble-shooting (e.g., control switch in pull-to-lock):P_value = 0.1.
- Failure events recoverable within 15 minutes without any significant trouble-shooting (e.g., resetting the turbine-driven AFW pump trip/throttle valve):P_value = 0.2.
- Failure events recoverable within 60 minutes without any significant trouble-shooting (e.g., resetting a pump breaker):P_value = 0.5.

These definitions could be used in combination with existing definitions of P_values that an event may get multiple P_value factors (e.g., partially degraded and recoverable within 60 min = 0.5 x 0.5).

B. Component Failure Rate Issues

DA.4: Failure Rate for Safety Valve Fail to Reclose

- NUREG/CR-6928 included Safety Valve and Safety Relief Valve failure to reclose passing liquid.
  - SVV FTCL, SVR FTCL, mean = 0.1, based on judgment with very limited basis.
- NRC Dataset (2015) eliminates these failure modes. It includes a new failure mode, PORV-Lquid.
  - Mean value 6.25E-2, given the evidence of <u>zero</u> failures and <u>seven</u> demands from 1987 to 2007 (NUREG/CR-7037).
- Suggestion: since the basis for the PORV-Lquid is both old data and very limited data with zero failures:
  - Update with recent failure event data.
  - Consider use of expert elicitation for this component failure rate if data is sparse.

C. Miscellaneous Data Issues

1. DC.2 to 4, Component Leakage
2. DC.5 to 8, Spurious Operation (SOP)
3. DQ.7, Basis for Error Factors

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C. Miscellaneous Data Issues

DC.2-4: Component Leakage Probabilities

Small Leakage failure mode (internal or external component leakage) is defined in NUREG/CR-6928 for valves, pumps, etc. as leakage from 1 to 50 gpm.

- This definition 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.
- It is not clear that the events used to calculate the Small and Large leakage probabilities define the actual leak rate. The data for these leakage probabilities represent old events (15 to 20 years old).

Suggestion: “Component Leakage” would be better defined for leaks in the range 10 to 50 gpm. For leakage below 10 gpm or above 50 gpm:

- External leakage > 50 gpm should be classified as an internal flood event and be excluded from this component reliability database.
- Internal leakage > 50 gpm could be considered a component failure (e.g., manual valve leakage > 50 gpm should be counted as Manual Valve Fails to Remain Closed).
- Leakage less than 10 gpm should be considered nuisance leakage which should not impact system performance.
- More recent data should be collected to better represent current component performance and maintenance practices.

Leakage in the range from 10 to 50 gpm is still a challenge to model (i.e., to understand the true impact of such a leak rate), but would help to focus the concern on more likely leakage events that may challenge system function over a period of time.

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C. Miscellaneous Data Issues

DC.5 to 9: Component Spurious Operation

NRC Dataset (2015) identifies events classified for:

- PORVs, Safety/Relief valves
- AOVs, MOVs, SOVs
- Breakers

Suggestions:

- Eliminate spurious operation as a component failure mode.
- The failure events should be either (a) considered as potential precursor events and addressed in the generic initiating event analysis; or (b) included as components failing over time (e.g., MOV fail to control)

C. Miscellaneous Data Issues

DC.5: PORV Spurious Operation

NRC Dataset (2015) identifies 24 events classified as PORV-SOP (PORV spurious opening), including both primary-side and secondary-side PORVs.

NROD Database search over the same time period (1998 to 2015) found 35 PORV-SOP events: 7 RCS, 28 MSS. Over the more recent time period (2006 to 2015), 16 PORV-SOP events:

- 2 RCS Events, PORV-SOP
  - 1 event occurred during troubleshooting and was immediately identified and recovered. This could be considered a precursor of SLOCA.
  - 1 event is a spurious closure event, applicable only when the PORV is already open. This would better be modeled as a Failure-to-Open event.
- 14 MSS Events, PORV-SOP:
  - 7 events involved the MSS PORV opening with no maintenance or plant operation in progress.
5 events occurred during maintenance or while the plant was shutting down or starting up.
2 events from one plant involved a frozen sensing line.
  - All events were quickly identified because of the impact on plant operation and quickly corrected, typically by taking the controller to manual or closing the manual isolation valve.
  - These events might be considered precursors to SLB initiators, although the actions to isolate the open MSS PORV should be highly reliable since the cue is generally clear and actions are straightforward.

Suggestions:

- Classify PORV-SOP as precursor events and include in the Initiating Event dataset (rather than with component reliability dataset).
- Separate this data between primary-side PORVs and secondary-side PORVs.

C. Miscellaneous Data Issues

DC.6: Safety/Relief Valve Spurious Operation

The NRC Dataset (2015) identifies a spurious-operation failure mode for several safety and relief valve types (SRV-SOP, SVV-SOP, SVV-SOP-PWR-MSS, and SVV-SOP-PWR-RCS) in addition to PORV-SOP.

A review of the NROD database identified 7 SVV-SOP events (3 MSS, 4 RCS), in contrast with the count of 11 in the NRC Dataset (2015). Of these 7 events:

- 3 were associated with a plant trip,
- 3 occurred when a unit was returning to normal pressure following a refueling outage,
- 1 led to a manual reactor trip.

For the most part, these are not random events; they occur in response to a change in plant configurations and some may not be actual failures.

Suggestion: These events should be re-classified as either

- Safety/relief valve opening during a transient, or
- Precursor events and include these in the Initiating Event dataset (rather than with component reliability dataset).

C. Miscellaneous Data Issues

DC.7: AOV, MOV, SOV Spurious Operation [1]

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.

- It is not clear whether these events represent internal valve failures or inadvertent actuation signals.
  - Based on a sample of failure reports from the NROD Database, these events include valves changing position due to inadvertent demand signals, due to setpoint drift, and due to switch failure. Generally these repositioning events were accompanied by an indication (alarm, valve position change).
- The naming convention and descriptions are not used consistently.
  - ID Names: the xxx-SC label is used for check valve spurious closure. The label xxx-SO is used for 3 valve types. Six valve-types are labeled xxx-OC. The OC label is used strictly for valves identified by specific system (CCW, IAS, SWS).
  - Descriptions: spurious operation, spurious opening, spuriously transfers, transfers open, fails to remain open.

C. Miscellaneous Data Issues

DC.7: AOV, MOV, SOV Spurious Operation (2)

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.

Suggestions:

- Use a consistent naming convention and descriptions for SOP.
- Resolve the inconsistency in counts from NRC Dataset (2015) to NROD Database.
- Review events to determine their classification:
  - Screen out failures that are outside the component boundary (e.g., inadvertent demand signal),
  - Classify some as valves fail-to-open or fail-to-close and include with active failure modes,
  - Classify some as precursor events and include in the Initiating Event dataset.

DC.8: Breaker Spurious Operation

The NRC Dataset (2015) identifies a spurious-operation failure mode for four types of circuit breakers:

- High voltage AC (13.8KV & 16KV, CBKHV-SOP); Medium voltage AC (4.16KV & 6.9KV, CBKMV-SOP); Low voltage AC (480V, CRB-CO-480); and DC (CBKDC-SOP).

Spurious operation of a breaker would generally be immediately alarmed in the control room.

- This would lead to breaker unavailability while the event was investigated and maintenance performed. Any such unavailability would be captured in the system/train unavailability.
- If this caused a plant upset leading to an initiating event, that should be captured in the IE frequencies.

A sample review of Breaker Spurious Operation failure events from the NROD Database identified that these events are commonly caused by a maintenance activity.

- In all cases, the spurious operation is alarmed, although in some events, the condition was discovered only during a test.

Suggestion: Based on the sample review, Breaker Spurious Operation contains (at least) two types of failure events:

- Maintenance events where the breaker spurious operation occurred as a result of some aspect of that activity. These events should be screened out as not applicable to an accident sequence. They may be related to precursor events.
- Test events where the breaker failed to remain closed. These events should be reclassified as Breaker Failure to Close. If the number of these events is comparable to the total number of “Breaker Failure to Close” events, then a standby failure mode should be added (Breaker Failure to Close while in standby) where the time between tests could be accounted for.

C. Miscellaneous Data Issues

DC.9: CCF Modeling of Spurious Operation

NRC CCF Dataset (2015) provides extremely sparse evidence of common cause failures for spurious operation failure modes:

- 0 events for check valves and DC circuit breakers,
- 1 event each for MOVs, AOVs, and 480 VAC circuit breakers,
- 3 events for 4160 VAC circuit breakers.

As discussed in #DC.6 and #DC.7, 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 displayed in the NRC CCF Dataset (2015) for spurious operation modes for valves and circuit breakers.

- For example, check valve spurious operation which has zero CCF events and zero independent events, but still produces a CCF parameter $\alpha2$ = 4.07E-2 (for CCCG = 2).

Suggestion: The spurious operation failure modes should be removed from the CCF Dataset based on the limited data for both independent and common cause spurious operation.

C. Miscellaneous Data Issues

DQ.7: Basis for Error Factors

- Data distributions in the NRC Dataset (2015) may not fully account for the uncertainties in the failure rate estimates.
- Error Factors range from 1.2 to 18.8, with about 90 of the 332 component failure modes having an EF less than 2.0.
- A number of uncertainties are not reflected in the raw number of failures and successes for a specific component failure mode:
  - 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 attributes such as manufacturer, size, process fluid, ambient environment, time-in-life, etc.
- Suggestion: develop a method of accounting for an expanded set of uncertainties that underlie the inputs into failure rates (and CCF parameters). It may be important to classify the types of uncertainties (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.
- For more details, see presentation *3Component Reliability Data UNCERTAINTY Issues for Discussion with NRC (FINAL).pdf* from January 2020 Meeting

Conclusions

- **PWROG**
  - We are available to support the development and review of the next revision to the NRC reliability and CCF databases.
  - We are open to options for how and when to provide comments.