

U.S. NRC Accident Sequence Precursor (ASP) Program Update

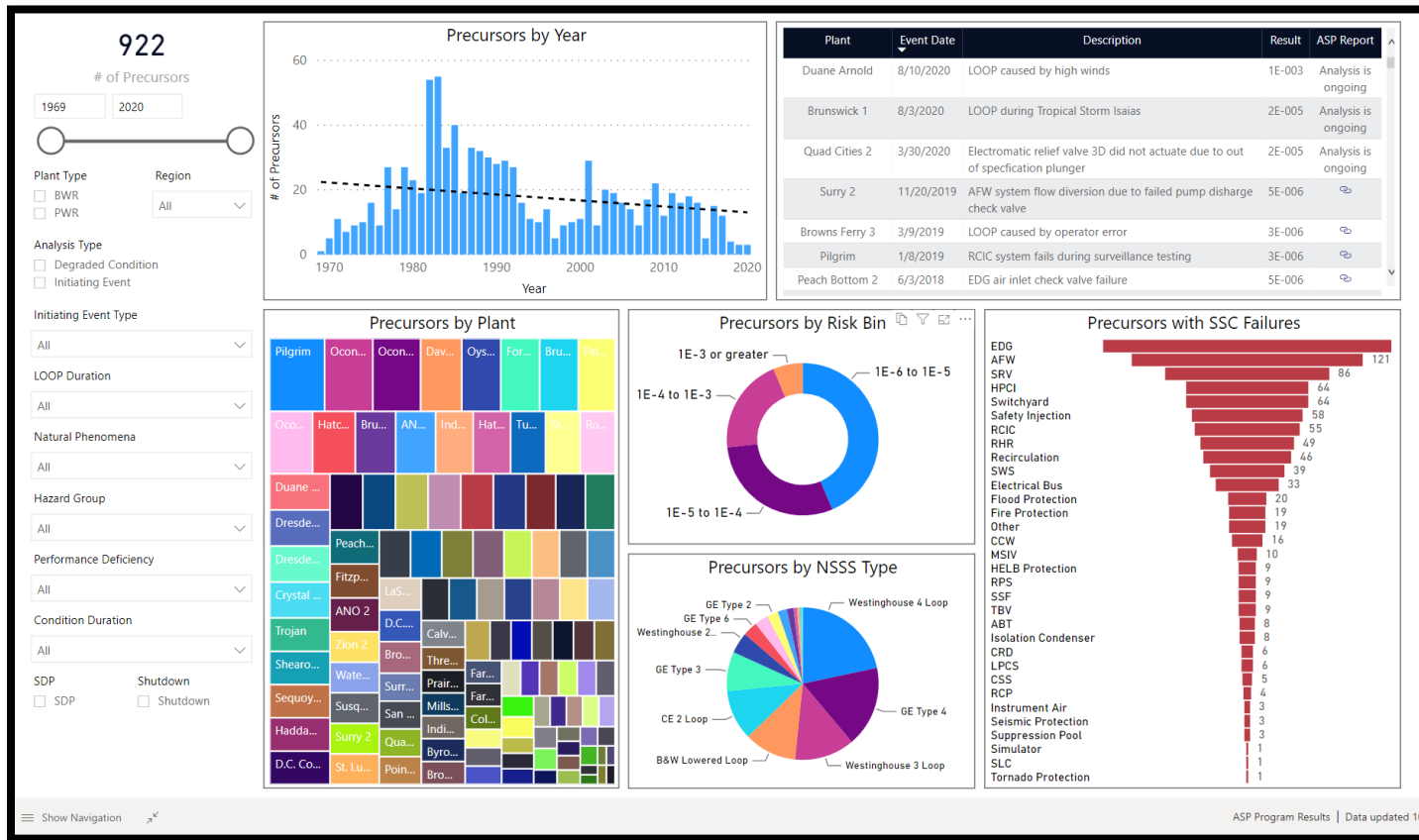
23rd PSAEA Meeting (November 2020)

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Program Changes and Challenges

- Increased focus on risk impact of hazards beyond internal events.
 - NRC standardized plant analysis risk (SPAR) models do not include all hazards (especially limited for internal fires).
 - Will evaluate qualitatively if needed.
 - The amount of licensee PSA information available can vary significantly between plants.
- Increased focus on uncertainties.
 - Evaluation and communication of modeling and parameter uncertainties is a challenge.
- Availability of ASP Program Information
 - Initial development of ASP Dashboard has been completed.
 - Currently working to make the ASP Dashboard publicly accessible.



ASP Program Results | Data updated 10/2020

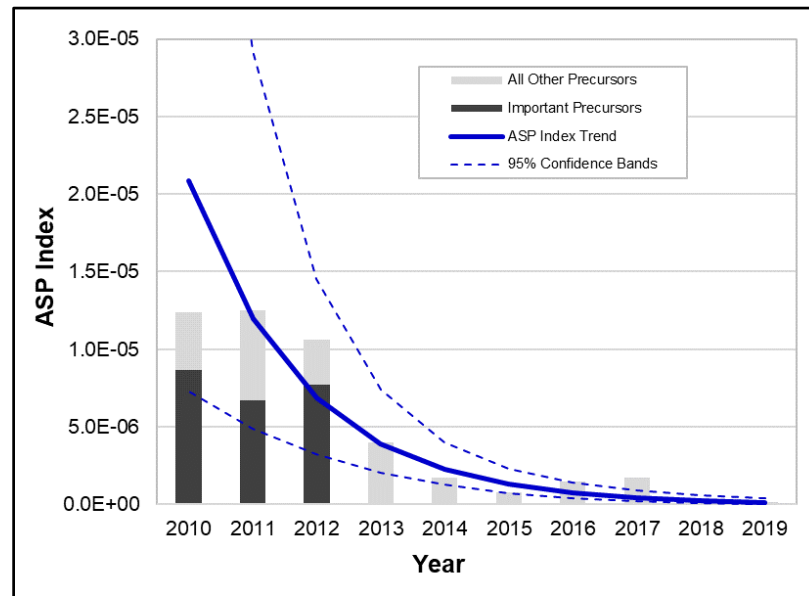
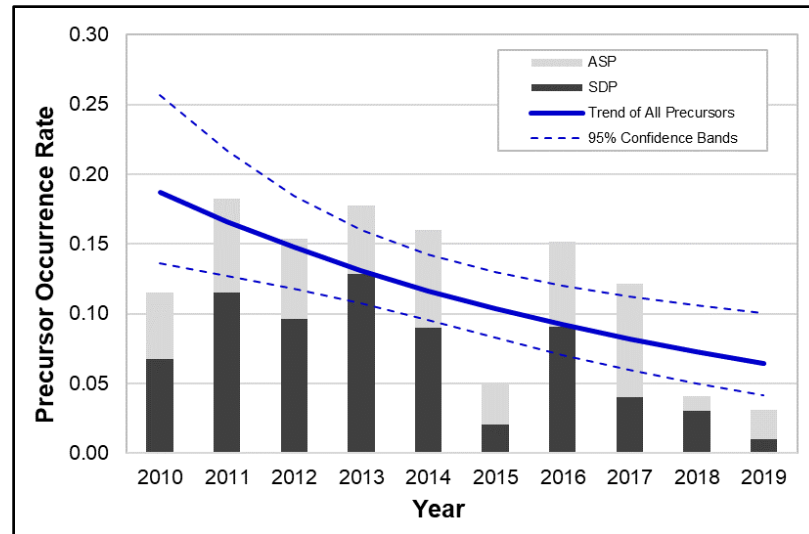
ASP Program Dashboard

ASP Results, Trends, and Insights

Precursor Trends

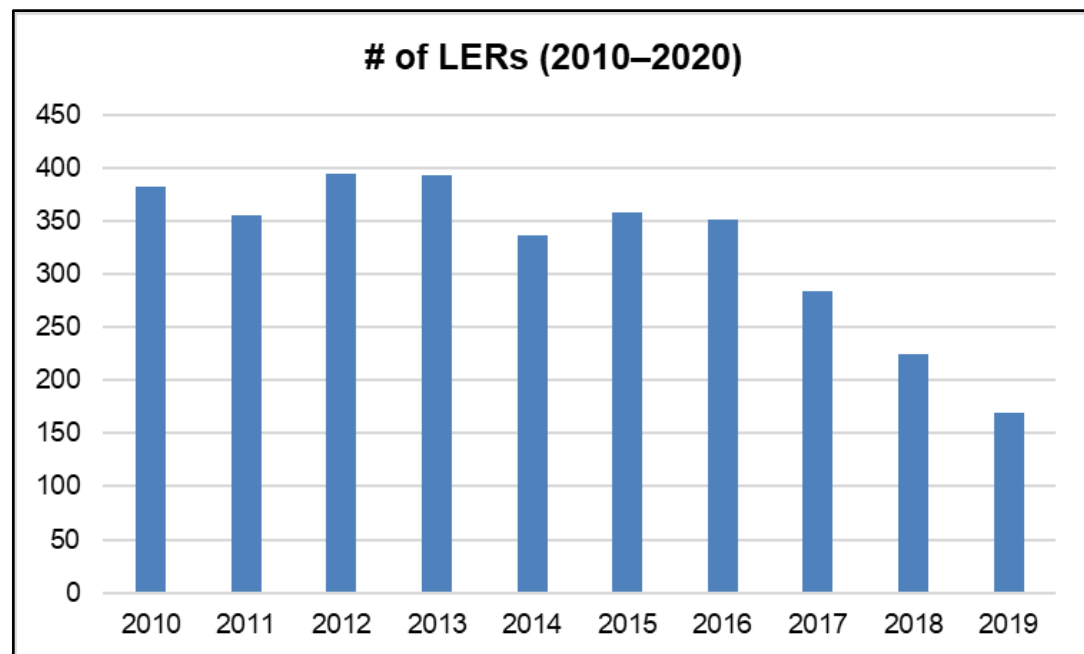
- The occurrence rate of all precursors and most precursor subgroups is decreasing for the past decade (2010–2019).
 - Higher-Risk Precursors
 - Initiating Events
 - Losses of Offsite Power (LOOPs)
 - Degraded Conditions
 - Precursors at Pressurized-Water Reactors
- No trend detected for emergency diesel generator (EDG) failures and precursors at boiling water reactors.
- There is also a decreasing trend of risk from all precursors as shown by ASP index.
 - The majority (51%) of total risk associated due to precursors is dominated by 7 precursors with $CCDP/\Delta CDP \geq 10^{-4}$.
 - The other 118 precursors contribute the remaining 49%.

Total Precursors and ASP Index Trends



LER Trends

- The number of LERs have reached historical lows.
- In addition, the number of LERs identified as potential precursors is decreasing.



Duane Arnold LOOP ASP Analysis

Sequence of Key Events

August 10, 2020

1138 Licensee entered abnormal operation procedures after a severe weather watch was issued; hourly checks of were initiated and the licensee suspended fuel movements

1235 Grid perturbation caused the two EDGs to automatically start and run unloaded.

1249 LOOP caused a main generator trip on reverse power automatic reactor scram. Running EDGs repowered safety-related buses.

1258 The licensee declared an Unusual Event.

2230 Shutdown cooling was initiated.

August 11, 2020

1600 Licensee exited Unusual Event after restoring offsite power.

Additional Information

- Wind speeds exceeded 80 miles per hour (mph) for over 20 minutes.
 - Peak winds estimated by National Weather Service to be near 130 mph.
- The main steam isolation valves (MSIVs) remained open throughout the event.
 - Operators aligned the main steam line drains to the condenser, which minimized the number of safety relief valve (SRV) demands to two.
- Firewater pump tagged out for maintenance.
 - Estimated that pump could be restored in ~1 hour.
- On August 12th, a small cut was discovered in the 5th floor wall of the reactor building that was the result of storm damage.
 - Subsequent test of the secondary containment boundary identified that the vacuum of 0.24 inches water (technical specification requirement is ≥ 0.25).

Analysis Assumptions and SPAR Model Changes

- Weather-related LOOP
 - No offsite power recovery credit provided prior to 25 hours.
- ESW Train 'B' Strainer Plugged
 - Inserted credit for operator to bypass plugged ESW strainers.
 - Applied causal alpha factor method (CAFM) for strainers (i.e., environment causal alpha factors were used).
- EDG repair credited removed for extended loss of AC power (ELAP) scenarios.
- FLEX Credited
 - Additional credit applied to stuck-open SRV sequences.
 - Inserted credit for firewater pump and technical support center diesel generator into FLEX logic.
 - Used multiplier for FLEX hardware reliability
- New MELCOR calculations for stuck-open SRV scenarios
 - Current models do not credit mitigation without offsite power recovery.
 - Results along with information provided by licensee indicated that sufficient time existed to connect FLEX makeup pumps or to restore the firewater pump.

Preliminary Results and Key Uncertainties

- Analysis is ongoing.
 - Potentially first significant precursor (CCDP/ Δ CDP $\geq 10^{-3}$) since 2002.
- Key Uncertainties
 - FLEX Credit
 - NRC and industry still working on developing realistic estimates for hardware reliability.
 - No detailed human reliability analysis performed yet.
 - Thermal-hydraulic calculations do not evaluate high-pressure coolant injection availability.
 - Increased potential for turbine-driven pump failure due to bypassing high level pump trips.
 - Issues with safe/stable end state