Mitigating the Impact of Single Points of Vulnerability

Summary

Failure of a single point of vulnerability (SPV) component can have significant impact on the reliability and economic results of a nuclear unit.

The answer is not a simple, "one and done" solution using a single tool or effort, but rather an ongoing process is required to capture, mitigate, and attempt to eliminate the SPV.

EPRI's R&D and expertise has created several tools, technical applications, and support documents to help the industry mitigate SPV.

Examples – Member Application

EXAMPLE 1: Utility SPV Tool Leverages EPRI's R&D: By applying EPRI's R&D results and working with EPRI's SMEs, a utility was able to customize their internal tools to achieve a more in-depth analysis of various strategies to maintain and monitor equipment identified as an SPV component. This effort helped automate tracking and provided improved technical basis documentation for better mitigation and decision making for SPV risks.

EXAMPLE 2: SPV Instrumentation & Control Card Focus: EPRI's R&D helped accurately identify weak points prone to failure, and then develop and implement measures to mitigate various SPV risks, with an expectation of reducing production and maintenance costs as well as improving equipment reliability related to I&C circuit cards.

EXAMPLE 3: SPV Spare Parts Program: EPRI's R&D was used to help develop and manage a new SPV spare parts program for a utility, providing the potential for significant economic benefits and aiding the engineering, maintenance, and procurement teams.

APPLICABILITY

All nuclear plants

VALUE

Applying EPRI's R&D should help mitigate the impact of SPV-related events, lessening or avoiding unplanned plant scram/trips and down-powers. Estimates from several utilities each calculated ***over $2M USD in annual savings*** from avoided trips and lost MW costs, as well as ***improved labor capabilities and efficiencies***. Industry estimates have shown a single plant scram is ***a $10M USD impact on the utility***.

EPRI PROGRAM

Plant Reliability and Resilience (PRR)

Background

By their very nature, complicated systems tend to have single points of vulnerability inherent in their design, and these will also change (i.e., increase or decrease) as improvements and modifications are made during the unit's lifetime. An ongoing process is needed to capture, mitigate, and eliminate SPV. Historically, many plants either haven't invested the time and energy to develop a robust program to address SPV, or developed a program but then stopped using it effectively.

As an example, one EPRI member shared how historically their storage and tracking of SPV program data was static with no common platform to maintain mitigation or elimination strategies, maintenance feedback, or monitoring requirements in one centralized location. This increased the likelihood of every SPV continuing to impact equipment reliability and causing MW losses, including an estimated 1.1M MWh of lost generation in a single year from SPV-related events.

EPRI's Role

For more than 50 years, EPRI has developed and refined countless tools, resources, guides, and subject matter expertise that can be used for SPV mitigation. EPRI staff can help the industry apply this R&D towards their SPV-related and other issues.

EXAMPLE 1: The EPRI PMBD is a well-known deliverable EPRI developed and keeps updated with world-wide industry operating experience and lessons learned. To attack their SPV issues, EPRI helped a utility stand-up a unique application programming interface (API) to automatically pull the latest maintenance templates to take advantage of the web-based capabilities of the PMBD. EPRI SMEs provided critical support to utility engineering and IT teams, helped the team evaluate the application to ensure the PMBD data was accurately being transferred and displayed, and were instrumental in resolving technical questions regarding equipment maintenance strategies.

EXAMPLE 2: The EPRI guidelines played a pivotal role in addressing various "pain points" and driving the utility's efforts. EPRI's R&D helped ensure the work was systematic and standardized, enabling the utility to clearly identify key points and challenges in the implementation process, and then develop targeted solutions accordingly. EPRI's inclusion of practical case studies and experience sharing within the guidelines greatly enhanced both the efficiency and technical quality of the implementation, with EPRI's SME provided ongoing technical guidance.

EXAMPLE 3: EPRI's SPV Process Guide was used to develop a comprehensive SPV management program, including formulating effective mitigation strategies for the SPVs, with a renewed focus on critical spares, and the establishment of the SPV spare parts list.

Value

Based on the unique situations and SPV for each member, it's challenging to highlight a single example that will be meaningful for everyone, and therefore several diverse examples are further expanded below.

EXAMPLE 1: A utility created an application which leveraged EPRI's Preventive Maintenance Basis Database (PMBD) to pull component preventative maintenance data, failure mode, and PM frequency information, to help improve equipment reliability strategies. This allowed for a much broader set of data to work with when managing the SPV program, and now users only visit one centralized tool to access information to make decisions related to the program.

EXAMPLE 2: Another utility used EPRI resources to construct a comprehensive reliability maintenance ecosystem, achieving full lifecycle management centered on intelligent maintenance strategies for instrumentation and controls (I&C) and their associated SPVs.

More than 120 SPV devices and a database of more than 400 vulnerable components was created, followed by developing 40 implementation guidelines, and conducting several failure mode and effects analysis (FMEA) exercises,

IMPLEMENTATION GUIDANCE

This is a multi-faceted issue and a single, "one-size-fits-all" approach doesn't apply.

The best way to mitigate the impact of an SPV at your plant is to contact EPRI's SME team (see contact info below) to discuss your specific needs, and then determine a path forward to apply the right approach and EPRI tool for your unique situation.

For example, EPRI has several technical applications prepared based on your needs including "*SPV Initial Program Development and Implementation Mentoring*," "*SPV Program Assessment and Mentoring*," "*Preventive Maintenance Basis Database (PMBD) Site-Specific Application Training*," and many others primed for mitigating SPV failures.

all of which created a new system for the full lifecycle management of the I&C cards.

Additionally, more than 20 specialized I&C circuit card and component testing and maintenance tools for printed circuit boards, power supplies, sub-rack calibration, thyristor, relay, and semiconductor automatic testing tools were developed thanks to EPRI membership. These new testing, diagnostic, and repair capabilities have improved reliability testing efficiency and should reduce labor costs.

The number of I&C SPV equipment work orders has decreased—a reduction of approximately 55% in 2024 compared to 2019—and the PM programs were optimized for more than 2,500 items. This helps with resource allocation, labor utilization, and should improve the reliability and stability of units and system equipment, as well as providing savings on outsourced testing and rental equipment fees.

EXAMPLE 3: SPV equipment management is essential to the plants' economic benefits. By managing the SPV spare parts list, the site can optimize both the inventory quantity and quality, thereby effectively supporting the on-site maintenance of SPV and significantly contributing to reducing the unit's unexpected outage time. This should help focus the attention on equipment management and provide more support within the limited operating budgets.

To support more effective technology transfer, EPRI is tracking implementation of key R&D activities.

Please access this link to provide input on your company's use of this particular research: https://www.surveymonkey.com/r/RHYFPTJ

Access additional Value Guides and examples of EPRI R&D application at: https://interactive.epri.com/nuclear-value/p/1

The system engineers developed an identification principle for SPV equipment and three categories for plant use. This was done using both quantitative and qualitative analysis methods, which helped identify critical spare parts for SPV equipment, and improved SPV equipment mitigation strategy and other management actions to enhance the quality of spare parts procurement.

Organizing procurement, management processes, and monitoring inventory of spare parts should enhance unit availability and shorten recovery time from failures. The SPV spare parts list has been officially released as a production technical document, bridging the gap in spare parts management.

Resources

- 3002025138, *Preventive Maintenance Basis Database (PMBD) v7.0*
- 3002023784, *Single Point Vulnerability (SPV) Process Guide Revision*
- 3002010685, *Critical Spares: Program Implementation and Lessons Learned*
- 1019162, *Plant Support Engineering: Critical Spares*
- 1007935, *Critical Component Identification Process – Licensee Examples: Scoping and Identification of Critical Components in Support of INPO AP913*
- Technical Applications|EPRI Micro Sites
- *Institute of Nuclear Power Operations' (INPO's) Industry Event Report L2-21-4*

EPRI CONTACT

CARL LANE, *Technical Executive*
678.822.4140, clane@epri.com

For more information, contact: **EPRI Customer Assistance Center**
800.313.3774 • askepri@epri.com

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EPRI
3420 Hillview Avenue, Palo Alto, California 94304-1338 USA • 650.855.2121 • www.epri.com