Diablo Canyon Uses EPRI Guide to Improve Work Planning

Work management at nuclear plants involves more than just the efficient scheduling of maintenance activities. An effective process gives close consideration to task complexity, safety, plant conditions, human factors, cost-effectiveness, workforce skills and specialization, and plant-specific needs.

Doing it right is critical to the effective operation and maintenance of the plant. In recent years the Institute of Nuclear Power Operations (INPO) and World Association of Nuclear Operations (WANO) identified a trend: shortcomings in work instruction and procedures have contributed to maintenance errors, an increase in inoperable equipment, component failure, the need for rework, work backlogs, and injury.

The Challenge: Ensuring Work Package Quality

Central to work management is the preparation of a work package, which sequences maintenance tasks by compiling key documents—work orders, work instructions, and supporting materials such as drawings, vendor manuals, weld process sheets, information on operating experience, human performance details, and special work process permits.

In 2004, INPO and the EPRI Nuclear Maintenance Applications Center (NMAC) formed a working group to develop an industry guideline addressing work package quality. The resulting document, Maintenance Work Package Planning Guidance (1011903), provides an overview of regulatory and industry requirements for work package content, level of detail, and quality, as well as guidance on skills and performance attributes essential for work planners and the personnel implementing the work packages.

The document establishes the structure, format, and content for work instructions—the primary elements of a quality work package—and uses a graded approach to work planning. With graded work planning, work packages can be prepared to varying levels of detail, depending on factors such as task complexity, potential effect on plant nuclear safety, reliability, and skill of the craft. The report also provides examples for measuring and monitoring the quality of work packages.

Application at Diablo Canyon

Industry evaluators at INPO identified weaknesses in work planning at PG&E’s Diablo Canyon Power Plant in California, and they formally designated work planning as an Area for Improvement. Plant staff turned to EPRI for help in taking corrective action and used the EPRI guideline document to implement improvements to the plant’s planning programs.

Plant staff also participated in the NMAC Work Planning Users Group, which meets twice a year to focus on continuous improvement of work packages.

The guideline document, combined with collaboration through the users group and the EPRI member network, helped Diablo Canyon staff identify and prioritize work planning issues and develop best practices. The staff established a work planning steering committee to monitor work package quality and assume responsibility for all work planning issues, including process, knowledge, safety, feedback, and human performance. Plant staff shared their experiences with the users group to further refine and develop solutions to their common issues.

Results: Measurable Success

Diablo Canyon made significant advances in its work package quality and planning processes, including a work planning training program, a computer-based feedback program, and enhanced metrics. INPO’s most recent review recognized the substantial improvement and closed the previously issued Area for Improvement. Moreover, maintenance errors due to planning weakness have been substantially reduced, with success documented in independent evaluations, internal reviews, and positive plant condition reports. Maintenance workers surveyed have noted improved content, consistency, and completeness of recent work packages, and the organization continues to seek areas of continuous improvement.

Effective work planning is an ongoing challenge at all nuclear power plants. Diablo Canyon expects to make further changes to its planning standards as a result of the electronic feedback process and continuous review and improvement of work package content and format. Adjustments will also be made to upgrade planning and work management computer software and to accommodate new workers who will replace retiring workers.

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**EPRI Studies and Field Tools Find Weak Link in Polymer Insulators and Offer Fixes to Improve Reliability**

Corona discharge caused by high electric fields can be a problem for polymer insulators, causing accelerated aging of rubber material on the high-voltage end of the insulators. To mitigate such deterioration and early failure, utilities have used corona rings to reduce the electric fields on lines operating at 161 kilovolts (kV) and above. In recent years, utilities have reported an increasing number of polymer insulation failures on 115-kV and 138-kV lines, suggesting that corona ring protection may be required also for these lower-voltage lines.

A recent EPRI study verified the problem by applying a variety of assessment tools, including advanced field inspection techniques, failure analysis techniques, electric field modeling, and equipment and failure databases. “The study was conclusive in finding that polymer insulator degradation can occur on 115- and 138-kV transmission lines in certain applications and that corona rings can eliminate the problem,” said Andrew Phillips, director of transmission research for EPRI. “Since we have been doing related research at our Lenox test facility for many years, we already had the tools in place to deal with the issue.”

A 72-page report (1015917) on this work provides reference information and resources to address the premature aging of polymer insulators. The report also provides recommendations for assessing existing insulators, replacing or retrofitting at-risk equipment, and specifying insulators for new or replacement units. “We also have ongoing dialogue with insulator manufacturers and standards committee representatives to advise them of what we have learned,” said Phillips.

**Assessing Deterioration**

Several EPRI members have already applied the research. “Because of our involvement in the EPRI insulators project, we were aware of these failures within the industry attributed to electrical discharge on lower-voltage insulators,” said Raymond Ferraro, a specialist in emergent technology and transfer at Public Service Electric & Gas Company (PSE&G). “With this information, we felt it prudent to investigate the possibility of electrical discharge activity on our recently re-conductored and re-insulated 138-kV lines.”

The assessment began with a review of insulators using the EPRI Polymer Insulator Vintage Guide (1012328), which tracks design and materials changes made by manufacturers over time. Next came discharge inspections of the insulators using the EPRI daytime corona camera.

“Once we verified electrical discharge with the daytime corona camera, EPRI worked closely with us to develop an approach to assess our level of risk for our installed insulators,” said Ferraro. “They also helped us formulate a suitable remediation plan and instruct our workforce on condition assessment of field units, which included developing a customized field guide.”

“For early detection and intervention, we were able to reduce the risk of possible insulator failure by identifying which insulators should be removed from service and where corona rings could be retrofitted to provide protection,” said Ferraro. “The results from this project allowed our re-conductoring project to continue, prevented polymer insulators from being installed without corona rings, avoided the need to replace a significant number of in-service polymer insulators, and established an approach for future assessments.”

**Advanced Modeling**

EPRI performed a similar assessment for Albuquerque-based PNM, which faces particular vulnerability at high altitudes, where corona problems are more likely. As a result, PNM removed units of a specific vintage and design, replacing them with units that have corona rings.

PNM’s Emilie Dohleman found EPRI’s advanced electric field modeling to be particularly valuable. “The three-dimensional modeling process really helped us in retrofitting existing insulators. This model showed precisely where the problem was, when a 2-D model probably would not have,” said Dohleman.

“EPRI’s long-term research in the area of corona effects and polymer insulator degradation was invaluable in assisting us in developing a cost-effective solution to this problem,” said Dohleman. “EPRI developed a utility-specific guide for evaluating existing insulators for continued use on the system. This not only saved the cost of new insulators but also avoided the added expense of staff time, equipment, and line outages.”

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