TECHNOLOGY AT WORK

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Engineering Fundamentals Training Prepares New Generation of Nuclear Professionals

Like other nuclear utility companies, Duke Energy provides technical orientation training to help new engineers make the transition from the classroom to hands-on work in the plant. For decades, Duke used off-site classroom training that was resource intensive and was burdensome to the students and their home organizations, requiring several weeks away from work. A reduction in new hires, resulting from industry downsizing, made the classroom approach even less cost-effective.

Now Duke and a growing list of other utilities are using EPRI's online Engineering Fundamentals Training Program to prepare new engineers for their careers in the nuclear power industry. The program consists of a series of computer-based courses and examinations that are accessed through the Institute of Nuclear Power Operations' National Academy for Nuclear Training e-Learning.

Use of these engineering fundamentals courses, packaged in discrete topic modules, avoids the cost and lost time related to off-site training and substantially reduces or eliminates the need for utilities to develop and maintain their own courses. Eight course modules are currently available:

- Basic Atomic and Nuclear Physics (1019164)
- Chemistry (1016696)
- Civil Engineering (1014968)
- Electrical Engineering (1014969)
- Heat Transfer and Fluid Flow (1016515)
- Mechanical Engineering (1012064)
- Nuclear Power Plant Materials (1014970)
- Process Control Systems (1016697)

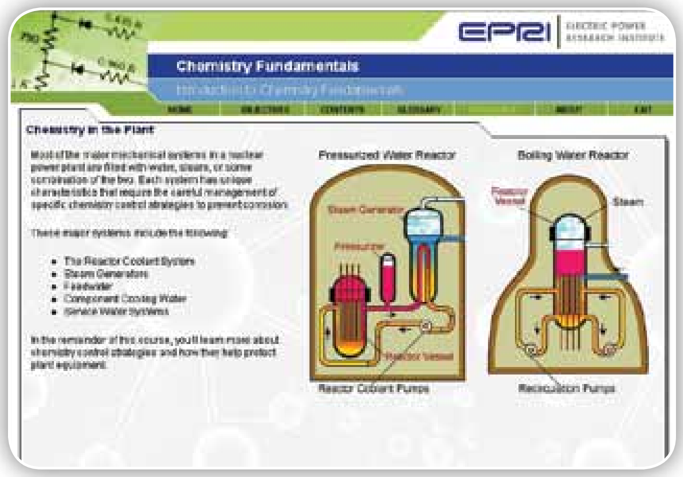
A Core Protection module will be added to the program in early 2010.

Engineers have completed about 2,250 training courses through October 2009, and EPRI continues to work with utility members to refine the content and examinations and to improve the program's effectiveness. Utilities can supplement the training with company- or site-specific information, as needed.

Developing a Better Approach

Duke had been looking for a better solution to technical orientation for some time and even tried a self-study workbook program developed by another utility. While this method eliminated off-site training, the workbooks focused on a standard engineering curriculum, offering few real-world nuclear specifics.

"We wanted to present information that was more relevant and practically applicable in a nuclear power plant," said Dr. Henry Nicholson, an engineering instructor at Duke Energy's Oconee Nuclear Station. "We also wanted to establish some consistency in the educational content for new engineers in common training programs—not only consistency within the individual utility fleet, but also within the national industry."



A course on nuclear plant chemistry is one of eight modules available in EPRI's online Engineering Fundamentals Training Program.

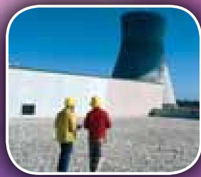
Duke and other utilities teamed with EPRI to develop a better approach. EPRI engaged utility working groups—including both engineering training specialists and subject matter experts—to develop the training modules. The working groups shared their experiences, their requirements, and their philosophies, choosing content that would expose new engineers to the full spectrum of engineering disciplines in nuclear plant operations.

"Rather than presenting an engineering topic from the perspective of the undergraduate engineering curriculum, the lessons incorporate physical, practical applications of the engineering discipline," said Nicholson. "There may be some fundamental engineering theory, such as basic electrical current laws, but there is also presentation of the applications of those engineering laws in the nuclear facility, such as overcurrent protection and breaker function."

A Wealth of Benefits

By focusing on practical issues and a range of topics, the EPRI Web-based training encourages understanding and cooperation among engineering disciplines in nuclear plants. It also standardizes orientation training and promotes a consistent knowledge base across the industry.

Through the Internet, students can access the modules and review the material when and where they choose and take the

exam when they're ready. EPRI member utilities can review and download the training materials from epri.com before logging into INPO's system.

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EPRI-NRC Collaboration Enables Revision of Pressurized Thermal Shock Regulations

The reactor pressure vessel is a critical safety-related component in nuclear power plants. Repairing or replacing this vessel in a pressurized water reactor (PWR) is not practical, yet its mechanical integrity must be conservatively demonstrated for 80 years or more of operation. Vessel embrittlement and the postulated effects of pressurized thermal shock have been of particular concern, and the U.S. Nuclear Regulatory Commission (NRC) issued a rule in the mid-1980s that limits the embrittlement allowed before additional evaluations or corrective actions are required.

One plant, Yankee Rowe, shut down prematurely in 1992, partly because of the high cost and difficulty of demonstrating pressure vessel integrity under postulated pressurized thermal shock conditions. Other plants have faced premature shutdown when it was expected they would exceed regulatory limits before reaching the end of their operating licenses.

EPRI's Materials Reliability program recognized the urgent need to address the issue with the latest knowledge and technology and developed a collaborative research program with the NRC to completely reanalyze pressurized thermal shock.

Defining the Issue

Pressure vessel embrittlement occurs during normal plant operation, when neutrons impinge on the vessel wall, reducing its strength and ductility over time. In accident scenarios where cold water is introduced into the reactor pressure vessel, rapid cooling could produce large thermal stresses that initiate cracks. During repressurization, these cracks could propagate in the embrittled vessel material, possibly breaching the vessel wall.

Although such a failure has never occurred, utilities operating older nuclear plants have found it difficult to adequately demonstrate reactor pressure vessel integrity by using the 1970s-vintage analytical assumptions in the NRC's original rule.

Some plant operators approached the problem by adopting costly strategies to reduce neutron exposure. Palisades Power Plant purchased fuel with a higher enrichment—at an increased cost of $500,000 annually—to maintain heat output while shielding bundles to protect the reactor pressure vessel from neutron impingement. Beaver Valley Power Station used hafnium suppression assemblies to reduce neutron exposure, at a cost of $1 million to $1.5 million per cycle.

Only one available alternative actually improves pressure vessel mechanical properties: an *in situ* thermal annealing heat treatment that costs $25 million to $30 million per unit.

A Complete Reanalysis

EPRI's collaborative approach was to get back to basics—to fully re-evaluate pressurized thermal shock with modern tools and knowledge and determine whether the 25-year-old rules were still reasonable or were overly conservative. The study incorporated technical advances and improved fundamental understanding in areas such as probabilistic risk assessment, fracture mechanics, thermal hydraulics, and human performance.

Researchers examined events that could initiate pressurized thermal shock, assessed their thermohydraulic severity, and applied new probabilistic fracture mechanics analyses to determine whether a range of assumed stresses were sufficient to propagate cracks through the vessel wall. Researchers ran millions of fracture mechanics analyses under a multitude of scenarios to calculate the probability of failure.

To ensure a sound, credible result, the collaboration included some 20 technical organizations, representing academia, national laboratories, utilities, vendors, contractors, the NRC, and EPRI. All parties shared results from individual research projects and provided independent technical input to one another's research.

Results

The reassessment demonstrated that pressure vessels are significantly more resistant to fracture than predicted in the original NRC rule. The research showed that the U.S. PWR fleet could operate safely through 60 years, and likely 80 years, and effectively eliminated pressurized thermal shock as a challenge to reactor pressure vessel integrity.

In response to the research findings, the NRC published a proposed revision to the rule in 2007, which is expected to become final in 2009. As a result, at least 12 nuclear plants will be able to avoid permanent shutdown, preserving about 15,000 megawatts of generating capacity.

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