THE *NUCLEAR NEWS* INTERVIEW

Richard Holman: Construction testing and startup engineers

A new fleet of nuclear power plants will require qualified construction test engineers and startup engineers, but will there be enough of them around?

Richard Holman is a certified performance technologist who is leading the Office of Training and Workforce Initiatives at the Center for Advanced Energy Studies, located at the Idaho National Laboratory. About a year ago, Holman and William Phoenix, an Idaho State University adjunct professor who is a retired nuclear startup engineer, started looking at issues that might affect the development of a new fleet of nuclear power plants in the United States. They studied the process of getting new plants up and running and asked themselves, "Once the COLs are approved, what next?" COLs are combined construction and operating licenses, which would be issued to a plant operator by the Nuclear Regulatory Commission.

Holman: "A successful construction and startup testing program ensures that a plant is ready for reliable operation."

Holman and Phoenix investigated the workforce needs of each of the component parts of the COL process, such as what it would take to get a COL approved on the regulator side, how many construction workers would be needed to build a new fleet, what would be the size of the construction management workforce (which consists of construction test engineers and startup engineers), and how smoothly the turnover from the construction effort to the operations side would take place.

Upon completing their research of historical data, Holman and Phoenix realized that there aren't enough construction test engineers and startup engineers available to work the number of anticipated new plant startups. According to Holman, about 40 construction testing engineers and 12 startup engineers are needed for each new plant. If 10 new plants go through the COL process—a conservative estimate, according to Holman—400 construction testing engineers and about 120 startup test engineers will be needed. Yet, Holman says, there currently are 600 construction test engineers and only 60 to 100 startup engineers remaining in the U.S. nuclear industry from its heyday in the 1970s, with half of them eligible to retire within five years.

Holman discussed this particular workforce issue with Rick Michal, *NN* senior editor.

What are the responsibilities of construction test engineers and startup engineers?

These engineers are highly trained technical people with a variety of talents and abilities. A successful construction and startup testing program, known as "commissioning," ensures that a plant's equipment performs as intended and that the plant is ready for reliable operation. The scope and activities of these jobs have some overlap. The construction test engineers prepare systems for operation by ensuring that their components are properly cleaned, assembled, tested, and calibrated and that they operate as a system. The end result is a functioning system that can perform to its design requirements. Construction test engineers must also be multidisciplined. Some systems consist entirely of electrical pieces or instruments, but most involve many different components. For instance, piping systems normally include pumps, valves, piping, electrical motors, instruments, and other parts.

Then there is the startup test engineer, who must be even more multidisciplined, with a broad, deep engineering understanding of individual components and systems and the complex interaction of all systems in a plant. Startup engineers receive the completed systems from the construction test engineers, write and conduct tests involving the entire plant, analyze the data, identify problems requiring resolution, conduct retesting, and verify that the plant operates as designed. The tests almost always represent the first time an evolution is conducted at a new plant. The startup engineer is also critical to the integration of the reactor core and the levels of testing conducted at increasing power levels. They write the reports that characterize the success or issues associated with the testing, including an overall final summary to the Nuclear Regulatory Commission. My partner in this effort, Bill Phoenix, has provided impeccable insights on the role of startup engineers based on his years in the industry.

How many of these engineers are still working in the industry right now?

A best guess would be that there are between 60 and 100 startup engineers left in the industry, of which half will be gone within the next three to five years due to retirement. For construction test engineers, the estimate is that there are likely more of these individuals left, on the order of about 600 working in a variety of disciplines, but still woefully short of what is required. And, basically, they have to be considered as unavailable because their positions would have to be backfilled if they were to move over to construction testing. Availability is a problem for the remaining startup engineers as well.

How many startup and construction test engineers were working in the industry at its peak?

Historically, there were about 40 construction test engineers for each nuclear plant, so even during the peak construction period for the present plants, there were only about 2200 construction test engineers. There were fewer startup engineers, probably only 250 at the industry's peak, with about 12 required per plant.

If current "new build" projections for nuclear plants hold true, how many of these engineers will be needed in the United States within the decade?

Right now, utilities have announced possible interest in building about 20 new plants, so on a long-term basis, about 800 construction test engineers and 250 startup engineers will be required. But, there are those that will be needed almost immediately if 10 to 12 new plants are initiated in the 2007 time frame. This means 400 construction test engineers and about 120 startup test engineers will be needed right away.

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The new plants will be less complicated and will enjoy far better project management tools, thanks to advances in computer-based techniques, but they will be under far more rigorous public and regulatory scrutiny and unforgiving time schedules. There are also new NRC restrictions on the number of hours that people can work, so the handoff between the crews must be effective, something that can be expected only from trained people who understand the testing. Fewer handoffs are better in order to avoid the loss of continuity, information, and progress. Further, any training effort would have to be larger than what is needed because some people will leave the utility for reasons such as new employment elsewhere. So, we need sufficient bench strength to do the job.

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What happens if the industry doesn't have enough of these engineers?

It could result in inadequate construction test programs, which would lead to overly long startup test programs as any problems from construction are remedied. This would delay taking the plants into commercial operation. At a cost of $1 million a day for being out of operation, a utility should be eager to have these skilled engineers on hand right away. Worse still is that a failure in the construction and startup test programs would result in a plant that operates poorly and unreliably for years. There is some thought from those we talked with in the industry that the Three Mile Island accident resulted in part from a poor commissioning program that left too many equipment problems behind.

The fact is that trained and experienced construction and startup test engineers satisfy three crucial needs: First, they bring numbers to augment a plant's staff. For example, for those existing plants that plan to add another reactor, the existing maintenance and operating staffs cannot possibly cope with the sheer magnitude of the new-plant work. A power plant typically has more than 100 systems, and each system has tens to hundreds of components. So, a plant's existing staff can't be stretched in order to deal with the new reactor's work. Second, these engineers bring the experience, knowledge, and focus required to complete the work without damaging equipment and to quickly identify and resolve problems. Third, they know how to complete testing on schedule.

Wouldn't the current testing that is done after refueling and maintenance activities cultivate the skills needed to address the work scopes for new plant startup and testing?

Some techniques apply, of course, such as flushing and hydrostatic testing, fuel loading, and core physics testing. This is good experience, but it is not new construction or startup. With new construction, every piece of equipment is new and the procedures for testing the equipment are new and untried.

Is an apprenticeship period needed to cultivate these engineers?

Well, we don't believe that a utility could take a fresh college graduate and drop him into one of these positions. Years ago, the standing joke was that a startup engineer's experience was measured by the amount of ruined equipment he left in his wake. The industry was fortunate then to have a relatively large number of experienced ex-Navy nukes to draw upon, and

even they required at least one startup to become proficient. Others with less experience, and particularly people who were both construction and startup engineers, felt they hadn't really mastered their trade until they had done several startups. There was no formal training program, and to become really good took about 10 years.

The nuclear industry no longer enjoys large numbers of experienced ex-Navy people and is faced with staffing existing and new plants with a relatively small pool of workers. The inefficient approach of learning construction and startup on the job simply won't work. I should add, though, that integration of new college grads into this system is necessary as part of succession planning and knowledge transfer—two issues of critical importance to the nuclear industry's workforce planning and development efforts.

What should be done, then, to develop a new crop of these engineers?

A formal training program should be established to produce reasonably knowledgeable people in about two to three years of part-time training. Training would rely on distance learning and video links for daily hour-long classes. Engineers would remain in their home organizations and could immediately apply their knowledge. With more intense commitment, the time frame could be shortened. The training would involve experienced engineers as teachers and mentors so that experience would be transferred. This mentoring would continue during the actual commissioning.

I'd suggest that about once every quarter, the students and mentors should spend a week or two at the Idaho National Laboratory (INL) for concentrated training on equipment and on subjects that are not suited to distance learning. This would also be the opportunity to begin building the necessary networks among these people so that they could turn to each other for advice and counsel within their own professional ranks. Creating a community of practice among these individuals will lead to much quicker, just-in-time problem resolution and information sharing than virtually anything else we can do. These people need to know each other.

The bottom line is that it's time to start moving. The first construction test engineers should be on site around 2011, and that is just over four years away. Training material and facilities must be identified and developed. Knowledgeable people must be contacted and available knowledge resources identified. Cooperative programs to exchange information and people, and to fund the training, must be established. The organizational aspects in preparation for solid, high-quality delivery could take upwards of a year, maybe longer.

Is anything being done on an industry-wide or federal level to address this problem?

The Center for Advanced Energy Studies (CAES) at INL has started a small grassroots proposal to develop these engineers. This effort was initiated by Bill Phoenix, a former startup engineer, in collaboration with a business-, performance-, and training-oriented ex-Navy nuke—that's me—and CAES's forward-looking director, Leonard Bond. The three of us are making a significant effort to identify and characterize the need, introduce the concept, and formulate a comprehensive training program. The current intent is to work with the Nuclear Energy Institute, the Institute of Nuclear Power Operations, EPRI, vendors, utilities, and regulators to determine the interest and commitment to bringing such a coordinated effort to fruition.

The problem is that this effort requires funding from a wide industry base over the next three to five years. The payback is enormous when considering the consequences of undertrained people in this area. The participating contributors will be rewarded for their support and participation. Every day lost in starting up a new plant would cost the utility a lot of money, so the time saved by training will be repaid many times over.

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How has this issue slipped under the radar?

New plant construction has been discussed for several years, but when the training of construction and startup engineers is mentioned, the response we get most often is, "Wow, we never thought about that." There is just a general lack of awareness. There has been virtually no venue to cover commissioning issues and no conference papers on commissioning activities, so it's gone unnoticed.

Would the NRC be affected by the lack of these engineers?

The NRC has recently hired engineers and is probably ahead of the rest of the industry in obtaining people. When the present fleet was commissioned, there was one person in Washington, now retired, who reviewed the startup reports and commented on the startups. Initially there were no resident inspectors, and the knowledgeable regional inspectors have largely retired.

Recognizing that a strong nuclear industry requires a strong, knowledgeable regulator, the INL approach would train the regulator in separate classes from the utilities or by other methods that preserve the necessary distance between the regulated and the regulator. INL is neutral, with no particular ties to utilities, vendors, or regulators. The goal is for regulators to be comfortable and knowledgeable with the testing and have the insight and knowledge to quickly recognize problems without unnecessarily stopping or delaying testing. The pace of testing will be so fast that effective monitoring will have to closely follow the testing. The ultimate goal of a common curriculum here is to promote a common language among all of the players by using a uniform set of courses and information that facilitates a shared understanding. This will, I believe, lead to quicker problem-solving and agreement on what approach to take in resolving identified issues.

Have utilities started programs to capture the knowledge of their retiring engineers from these fields?

For many years, utilities have made a concerted effort to capture knowledge in procedures. Procedures provide instructions but cannot effectively convey the depth of understanding and experience that went into their development. This is the so-called "undocumented tacit knowledge" that is of wide concern among those of us involved in the knowledge capture and management arena.

When people leave a company, they often take with them vast amounts of knowledge and experience that were essential to problem-solving when the plant was started up. When procedures already exist, it is difficult for already short-staffed utilities to spend time or energy capturing this knowledge, so it literally walks out the door. Up until recent years, there has been little in the way of tools or a systematic approach to knowledge capture, retention, management, and reuse. This is being remedied, but unfortunately, in the area of previous startups

in the United States, most of the talent may be gone. Part of our effort will be to identify those individuals and capture what we can, and potentially enlist them as mentors, subject matter experts, and possibly as instructors.

What are some of the areas being considered for curriculum to train a new crop of these engineers?

At this stage it is better to outline the overall general objectives. Most engineers are specialists and will need a far broader knowledge to be effective test engineers. Concepts and fundamentals—the "why" rather than the "how"—will be emphasized so that they will have the insight and practical first-principle knowledge to solve problems. They will need to understand the interrelationships of components and systems, particularly during complex integrated plant operation.

The goal is to produce multidisciplined engineers with a broad yet deep knowledge that includes engineering, licensing and regulation, plant chemistry, problems and solutions of past startups, interpersonal relationship skills—including craft management for construction engineers, scheduling and project management, data analysis, effective writing and presentation, conduct of operations and testing, and plant operations. Engineers should have component-level and system-level knowledge. They should know what has worked well during previous startups and the pitfalls and poor practices to be avoided.

In time, a seasoned startup test engineer will have the knowledge of plant operation approaching that of a senior reactor operator, and the thorough theoretical and practical knowledge of a professional engineer in the four major engineering disciplines required for testing: mechanical, nuclear, electrical, and controls systems. He or she will also know how the applicable regulations are incorporated in the design of the system and the plant's documentation, particularly the final safety analysis report. This person will be aware of the available industry research and how to apply it to equipment and problems encountered. This is, however, as much about people skills as it is about technical skills, and our approach to this training effort will emphasize a strong tie between the two.

Training will require time and commitment by organizations and individuals. The alternative is on-the-job training of contractors, something we think no utility can afford, given current public scrutiny and the present commercial and regulatory climate. As our CAES director, Leonard Bond, has observed, "The future safety, effectiveness, and productivity of our new plants will be integrally tied to the conditions under which we construct and start them. These engineers are the guardians of those conditions." NN