The app includes realistic animation, voiceover narration, and interactive features to give users enhanced work instruction on air-operated valve maintenance. (Photos: EPRI)

Nuclear plant maintenance: There's an app for that

By Nick Camilli

A first-of-its-kind software application delivers step-by-step guidance, with 3-D animation and sound, to a maintenance worker's tablet—and provides a glimpse of the future of electronic work packages.

The old saying "A picture is worth a thousand words" could not be more true than when applied to maintenance tasks. Although printed words can carry a great deal of information, adding pictures provides greater value for a worker who is disassembling, inspecting, and repairing a critical component. Now imagine maintenance instructions delivered through a realistic, three-dimensional video, with audio narration offering step-by-step guidance for performing work on a specific component, just as it would appear in a power plant or on a workbench.

A new software application provides just such a capability for the maintenance of a common component in nuclear power plants, air-operated valves (AOV). The prototype app, developed by EPRI's Nuclear Maintenance Application Center, includes the following:

■ User interaction to improve knowledge transfer and to provide practice on upcoming maintenance activities.

■ Component familiarization through in-

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The air-operated valve maintenance app captures the knowledge of seasoned experts and makes it available to a new generation of maintenance workers.

Tools and components appear as they would in a real work environment. View clips on EPRI's YouTube channel at <www.youtube.com/eprivideos>.

teractive and animated 3-D cutaway views and exploded diagrams.

■ An immersive task-based trainer to properly disassemble, inspect, reassemble, and troubleshoot the AOV.

■ Pop-up boxes to alert users to important tasks and/or cautionary measures.

The app, which was developed and tested with significant input from Duke Energy, Exelon, Korea Hydro & Nuclear Power Company (KHNP), Électricité de France, Chubu Electric Power Company (Japan), and the Tennessee Valley Authority, is available in Windows and Android versions and can be downloaded for use on laptop and desktop computers or mobile tablets.

Three video clips from the AOV applica-tion have been posted to EPRI's YouTube channel at <www.youtube.com/eprivideos>. The clips are titled Air Operated Valve Overview, Air Operated Valve Removal, and Air Operated Valve Disassemble.

Genesis of the concept

The development of the AOV app is part of a broad effort by EPRI to improve the de-

The app employs high-resolution, detailed depictions of component parts and step-by-step instructions for performing maintenance tasks.

livery of maintenance information in order to increase maintenance productivity and work quality.

For decades, nuclear power plants have relied on EPRI's equipment guidelines and reports to optimize maintenance practices and ensure high levels of equipment reliability. Effective maintenance plays a critical role in a unit's ability to maintain high safety, reliability, and capacity factor levels. To this end, maintenance practices must be continuously reviewed and updated based on industry operating experience and emerging issues.

Emerging issues and the spirit of continuous improvement spurred EPRI to seek an advanced method to deliver maintenance best practices to plant workers beyond the traditional hard-copy report. One issue involves the struggle to capture the knowledge and experience of seasoned staff and transfer it to the new generation of workers. Inefficient knowledge transfer and communication can result in worker errors, lost power generation, and lost revenue. Another issue is that getting EPRI information into the hands of maintenance workers (including supplemental workers) is not 100 percent effective, making new methods of information delivery desirable. Contributing to this issue is a cultural shift from paper to digital technologies, offering enhanced visualization, sound, and other features.

Electronic work packages

The development of the AOV application has opened up other research opportunities within EPRI's Nuclear Maintenance Application Center. Whereas the AOV app provides a look at the future of maintenance, modern technology could also be used to reimagine work planning. NMAC is contributing to industry efforts to replace the standard, paper-based work packages with electronic work packages that use mobile technology and electronic processes. Such a transition could improve worker productivity (more "wrench time"), increase the likelihood of successful task execution, and simplify the overall work management process.

Paper-based work packages typically require workers and supervisors to log into the work management system to manually update task status as the task progresses. This can distract workers and supervisors from the task itself. With an electronic work package, tasks can be linked to a plant's existing planning and scheduling software so that task status is more accurate. Moreover, task durations can be collected for future duration and man-hour estimates. Electronic work packages also would be able to link to the vast resources available through plant databases, including clearances, drawings, and prior work packages.

To address these issues, EPRI researchers envisioned a new approach that would improve the delivery of maintenance information using portable modern technologies already in use in the military and in the aircraft and automobile industries. The approach would provide field support capability for maintenance, troubleshooting, and inspection and would involve improved knowledge capture mechanisms. It would also support enhanced training and education of personnel, enabling users to learn, practice, and test their skills at any time or place, replacing traditional training workshops with a digital solution that does not require travel.

In addition, the approach would be based on existing EPRI information. Much of the information in conventional hard-copy reports lends itself to electronic delivery. Component disassembly/reassembly instructions, inspection criteria, troubleshooting, and preventive maintenance tasks, for example, can be compiled and pre-

sented in a visual manner that supports greater user understanding. More important, with modern technology, this information can be delivered to maintenance workers *prior to and while performing* maintenance activities.

This vision took shape in the form of a software application that would run on tablet computers, smartphones, or other hand-held mobile devices.

Development and testing

The project team selected air-operated valves for the app because there can be hundreds of them in a nuclear power plant. In addition, at the time the app was being developed, there were some industry issues related to AOV maintenance and training that hindered AOV performance. EPRI has developed an extensive knowledge base on AOVs and has published numerous reports and maintenance guidelines for nuclear power plant maintenance engineering supervisors and workers. This knowledge foundation is the first component of the app. The second component is enhanced

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delivery of the knowledge via 3-D animation, voiceover narration, and interactive features such as pop-up text boxes.

To develop the information delivery component, the EPRI project team visited Duke Energy's Harris nuclear power plant in North Carolina for a session with the plant's maintenance training instructor. The instructor completely disassembled, inspected, and reassembled an AOV model, explaining each step of the process in detail. Having captured the instructor's tricks of the trade in video and audio, the project team scripted each task on a series of storyboards, recorded voiceover narration to describe each task in precise detail, and developed a series of interactive text boxes to complement the audio.

EPRI then convened a technical advisory group of industry subject matter experts to review the prototype app to ensure technical accuracy. During an intensive two-day session, the group, which included experts from Duke Energy, Exelon, TVA, KHNP, EDF, and Chubu, examined and critiqued every aspect of the app and suggested revisions and refinements that the project team

incorporated. The revised prototype then went through a thorough quality assurance and debugging process. As a final step, the app was tested for functionality by industry experts in the technical advisory group.

EPRI has also developed a French-language version of the app, translating the voiceover and text boxes. This was done to test the diversity of the app and confirm that its framework, such as text boxes, was sufficiently flexible to accommodate more characters if necessary in non-English versions. The project team is in discussions to develop Korean and Japanese language versions.

Early uses, further development

Utility maintenance instructors are already using the app in mechanical and in instrumentation and control AOV training courses. Mechanics are using the app's extensive instruction content for pre-job preparation and for quick refresher training before going into the field to perform work.

The use of the AOV app at nuclear power plants is among its intended applications, but this is currently limited by the lack of mobile devices in the field. Moreover, only a few plants are currently equipped with wireless technology to support this approach to information delivery. It's just a matter of time, however, before the use of tablets and other mobile technologies for maintenance work increases, along with the installation of in-plant wireless networks. When this happens, a world of resources will open to maintenance personnel.

Equipped with tablet computers instead of thick three-ring binders, workers will be able to quickly summon information on specific components and tasks. At present, a worker seeking additional information for a job has to contact a supervisor or engineering personnel for answers. If the worker is in containment, this process might entail exiting containment, changing clothes, going to the supervisor's location for instructions, and then reversing the process to return to the worksite. Having live access to electronic information would streamline and transform this process, saving time and money.

Although only recently released, the AOV app has been well received, and user feedback has been very positive. The most common feedback comment is the question, "What is going to be the next app?" The answer: EPRI is currently working on a bolting app that describes the importance of proper bolt torque and gasket selection. An effort is also under way to develop an app for K-Line circuit breakers. Meanwhile, the AOV app is undergoing additional enhancement with the addition of diagnostics testing features.

The future will bring further development, as nearly all maintenance activities—including assembly, disassembly, inspection, and testing—are amenable to the use of apps. **N**