CHECKING IN

WITH THE CHECWORKS™ USERS GROUP

"Corrosion isn't an exact science. It depends on so many small, unique, local variables. CHECWORKS software helps identify what piping is most susceptible to flow-accelerated corrosion ... CHECWORKS is a way to set priorities."

– Doug Munson

As water or steam runs through steel piping, year after year, the pipe walls begin to thin. Eventually, the piping may leak or rupture, possibly endangering personnel and plant operation.

A major cause of pipe wall thinning in water and steam systems is flow-accelerated corrosion (FAC), which occurs when there is turbulent or fast-flowing water or wet steam that wears away the oxide buildup inside the pipe. The exposed metal corrodes again and the cycle is repeated many times, accelerating the corrosion process. Predicting the amount of wear caused by this type of corrosion is complex, because metal loss comes from a combination of many factors, including water chemistry, pipe composition, and how the water or steam flows through the pipe.

Twenty years ago, four workers died and others were injured in the major pipe rupture at Surry Power Station described in Significant Operating Experience Report 87-3, *Pipe Failures in High Energy Systems due to Erosion/Corrosion*. This was the impetus for developing improved FAC programs to identify, monitor, and mitigate flow-accelerated-corrosion-related damage in advance of failure. Since then, the frequency of FAC-related events at U.S. nuclear plants has declined significantly, and there have been no FAC-related injuries at U.S. nuclear plants.

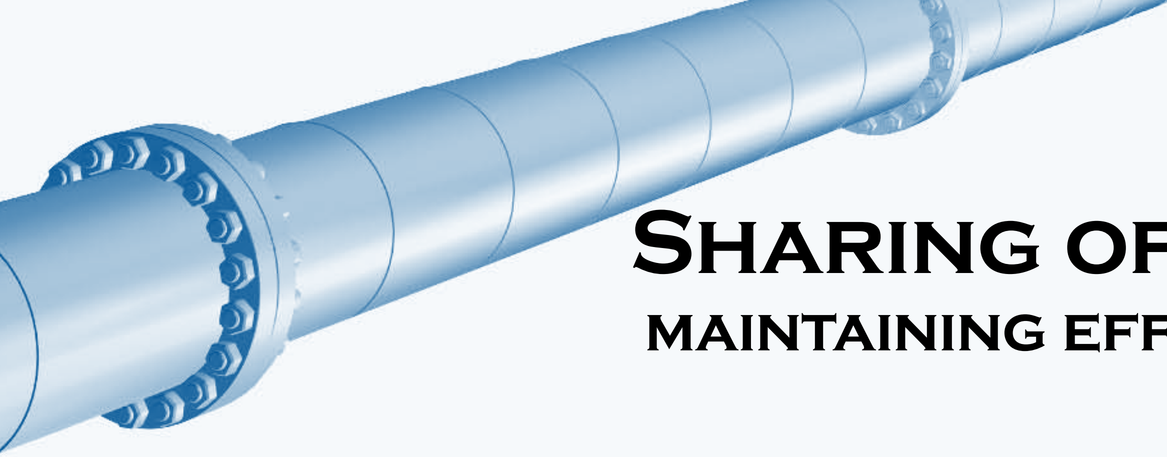
That improvement has been driven by changes in water chemistry that reduce corrosion, but another important factor is the Electric Power Research Institute's (EPRI) development of CHECWORKS software that helps identify what piping is most susceptible to FAC. Says Doug Munson, EPRI's main consultant for CHECWORKS, "Corrosion isn't an exact science. It's not like manufacturing something, where if you use the same amount of material produced in the same way, you end up with the same product. It depends on so many small, unique, local variables. In a typical power plant, there may be 5,000 susceptible components, but the plant may only be able to inspect a hundred during an outage. CHECWORKS is a way to set priorities."

The CHECWORKS program has continued to be upgraded based on input and data from the users group and improvements in computer and imaging technology. The latest version includes an open database that allows users to generate custom reports.

CHUG spreads information, experience

With the development of CHECWORKS came the CHECWORKS Users Group (CHUG). Munson says, "The users group has been extremely beneficial in disseminating information and exchanging experiences between utilities so that what happens at one site is quickly known by everyone else."

Recent non-U.S. FAC-related events, as outlined in the October 2006



Sharing operating

maintaining effective flow

Significant Event Report 5-06, *Flow-Accelerated Corrosion*, show what can happen without close monitoring of flow-accelerated corrosion and repair or replacement with FAC-resistant materials. The use of CHECWORKS and industry guidelines for effective programs, which have helped reduce U.S. events, is expanding to plants worldwide. CHUG's members represent 260 nuclear plants, including all U.S. plants plus plants around the world in Canada, Mexico, Taiwan, Korea, Japan, Spain, Belgium, France, Czech Republic, Romania and Slovenia.

Sharing information

Sharing operating experience is a crucial part of maintaining effective flow-accelerated corrosion programs. CHUG members meet twice a year to exchange information and operating experience. The two-and-a-half-day meetings include presentations of operating experience and opportunities for people who have problems to present them to the group. David Smith, flow-accelerated corrosion coordinator in the Duke Energy corporate office, says, "In my opinion, the biggest benefit is that it creates a forum for the entire industry to get together and share information."

"We also use the meeting as an opportunity to mentor newer FAC managers," says CHUG Advisory Committee chairman Aaron Kelley, Exelon Nuclear's LaSalle Station flow-accelerated corrosion program manager. "They often have a lot of questions about how to evaluate operating experience and manage their programs." Additional interactive sessions and workshops for new FAC managers are planned for future meetings.

The CHUG Web site is also a resource for sharing information. It includes FAC-related documents and lists of mentors who can help with flow-accelerated corrosion issues. Says Kelley, "You can post messages and pictures and get an immediate response."

The information shared through CHUG can also help ensure a smooth turnover as FAC coordinators retire. With CHUG's input, EPRI is planning to add training for new flow-accelerated corrosion engineers this year. "There was training in the use of CHECWORKS and in the mechanism of FAC, but not on day-to-day responsibilities such as how to plan for outages; inspect components; evaluate data; and make repair and replacement decisions on a long-term basis," Smith says.

Using CHECWORKS

To use CHECWORKS, FAC coordinators input the condition of the susceptible lines, including piping design, water chemistry, piping composition, pressure and temperature. From that, CHECWORKS calculates the wear rate, and FAC coordinators set inspection priorities based on what piping is most susceptible to flow-accelerated corrosion. The data from those inspections is entered back into CHECWORKS, which determines the actual wear rate and recalibrates itself.

"There are miles of piping in our plants," Kelley says. "You can't inspect it all. We continually use the model to pick areas to inspect and feed data into CHECWORKS, which keeps refining the model. If anything changes, for example, a power uprate, that information is put back into the model. It's an ongoing cycle, a living program." The more data that is entered into CHECWORKS, the better the program analysis reflects actual plant conditions.

Pipe inspections use a variety of non-destructive examination techniques, including the ultrasonic testing measuring pipe wall thickness that is fed into CHECWORKS.

"You have to evaluate what the model is telling you," Kelley says. "The model does not spit out an inspection scope. You have to apply engineering judgment to come up with good inspection locations." FAC coordinators also monitor piping that is not modeled by CHECWORKS, mostly small bore piping, which amounts to three to four times more feet of pipe.

Elements of an effective program

About 10 years ago, EPRI, working with CHUG, developed *Recommendations for an Effective Flow-Accelerated Corrosion Program* (EPRI NSAC-202L-R3) to help utilities design and implement a comprehensive FAC mitigation program. The document, on its third revision, outlines all aspects of an effective FAC program, including documentation, inspection, water chemistry, materials and strategies for small bore piping.

EXPERIENCE ... IS A CRUCIAL PART OF -ACCELERATED CORROSION PROGRAMS.

It identifies six key elements for an effective program:

- Long-term strategy
- Corporate commitment
- Analysis
- Operating experience
- Inspections
- Training and engineering judgment

"Probably number one on my list would be a long-term strategy," Kelley says. "A long-term strategy and corporate support are necessary for all the elements to work. With pressures to reduce costs and outage length, we're continually challenged to support the inspection scope and the number of piping replacements we do proactively during outages. We have to make sure that we are doing what really needs to be done."

Bill Klein, flow-accelerated corrosion program owner at Florida Power and Light, says one example is making a business case for replacing a degrading line with FAC-resistant material. Inspection data and the trending wear rate may indicate that a line will exceed its useful life in the not-too-distant future. He says, "If it's going to fail, we're going to have to replace it eventually. Upgrading to a FAC-resistant material can reduce the frequency of inspections and the time and manpower needed for inspections."

Flow-accelerated corrosion control is one aspect of a life-extension strategy. "We can eliminate degradation by changing pipe materials," Smith says. "If we change to wear-resistant materials, it really doesn't matter if the plant life is 60 years rather than 40 years. We have to look at the economics of running 20 more years. If we have to inspect that line five more times, we can possibly save money by just replacing it."

Another challenge is how to prioritize inspection of the thousands of feet of small bore pipe that is not modeled by CHECWORKS. Andy Barth, FAC program owner at V.C. Summer Nuclear Station, says that they recently did a risk ranking of small bore piping, classifying the piping into three groups:

- Failures that could cause a plant trip or personnel injury
- Failures that won't directly trip the plant, but might require an outage or downpower to fix
- Failures that can be safely isolated

"A pipe failure is never good," Barth says. "However, by prioritizing potential pipe failure into specific categories based on risk to personnel safety and the operation of the plant, we know where to focus our inspection efforts."

Looking back at the last 20 years of operating experience, Ian Breedlove, a mechanical engineer who has been involved with the FAC program at Surry since its inception in 1986, says that the most important improvement is the computer software. "What's also important is the backing of your management to do a thorough job, good inspection programs, and a long-term plan for what to inspect and what to replace," Breedlove says.

Harold Crockett, EPRI project manager, takes a pragmatic view of the issues. "There will always be some level of leaks and failures, but where the EPRI CHECWORKS process has been applied, these leaks have been limited to low-consequence locations." ■

Contact: *Aaron Kelley, (815) 415-3843, aaron.kelley@exeloncorp.com; Harold Crockett, (704) 595-2248, hcrockett@epri.com.*