NUCLEAR POWER INTERNATIONAL

'Smart' Technology Upgrade at Bruce Power

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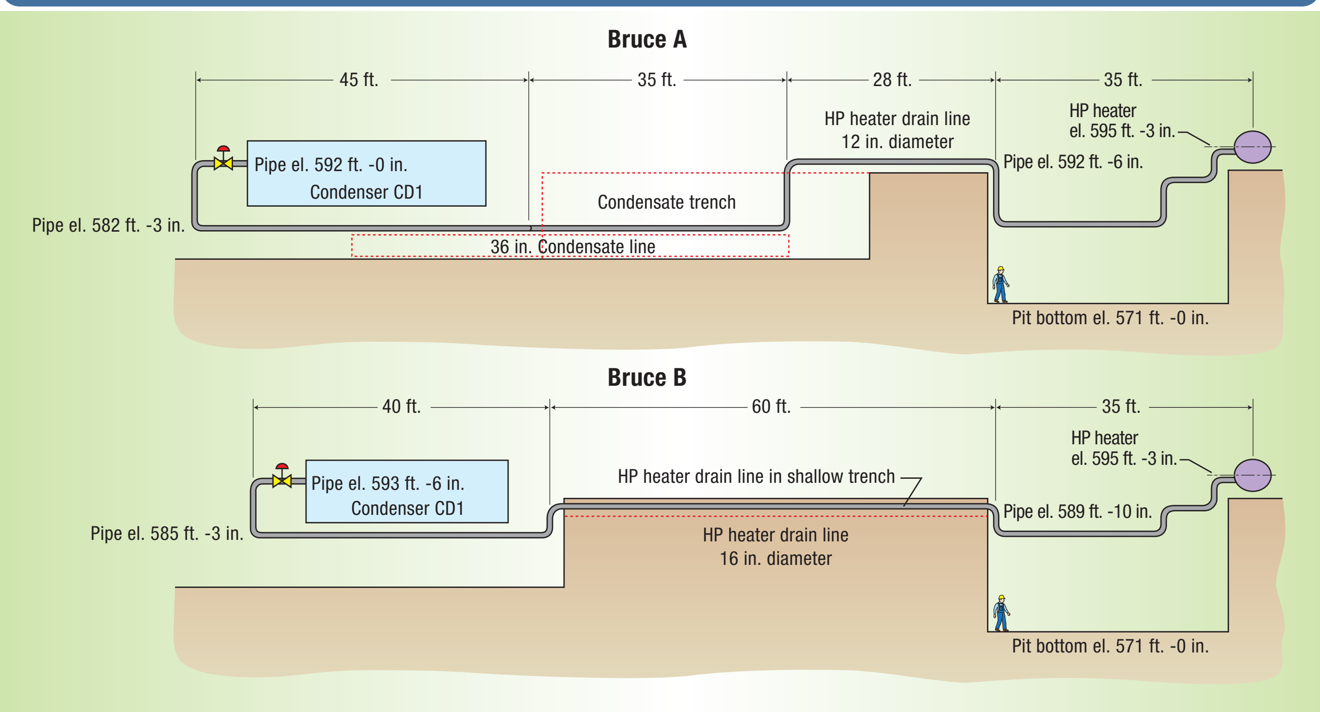
Bruce Power has a history of feedwater heater operating problems. Steam hammer has been a common problem on the HX5 drain lines in all eight units at Bruce Power in Ontario, Canada, since early in its operating history. Several stop-gap measures were tried over the years with limited success. When a comprehensive root-cause analysis was initiated in 2001, it pointed to two main causes for the problems: an inverted loop in the saturated drains that allowed liquid to collect and inadequate heater level control.

A third-party review of this study along with an intensive operating experience (OPEX) database search confirmed that these were common problems with feedwater heater drain lines. Based on this study, a project was raised to correct the problems.

In the meantime, procedures were modified to try to mitigate the impact while the project was being studied further. Essentially, the new procedure required that the heaters be isolated until the units reached full power. While this did reduce the water hammer problems, it was costing the unit money in terms of reduced efficiency and required a lot of manual intervention to implement. Due to these problems, station management decided to proceed with the modification as originally scoped.

The project goals included removing the inverted loop in the drain lines and performing a comprehensive upgrade of the controls, using state-of-the-art digital technology. Figure 1 shows the original piping configuration and the inverted loop in the drain line. Removing the inverted loop would require boring a hole through the 15-foot-thick concrete bulkhead as

Figure 1 ORIGINAL PIPING CONFIGURATION



shown in Figure 1, so that the new layout would end up as shown in Figure 2. The end-game for the project was to eliminate the water hammer and reduce the amount of manual intervention required for optimal feedwater heater operation. This would increase unit efficiency while reducing the cost of obtaining satisfactory operation. Essentially, improved financial performance would pay for the modification.

TIGHT IMPLEMENTATION SCHEDULE

Once they got the go-ahead, team members had only seven months for full implementation if the installation was to be done during the next outage. They looked for vendors that could take on a turn-key approach to the project and decided on Lakeside Process Controls and Canadian Power Utility Services (CPUS).

CPUS found Robinson Contracting, a Canadian firm with horizontal boring experience. Preparations were made to drill the hole completely through the bulkhead on a schedule that would support implementation during the 28-day outage.

While Robinson Contracting began preparations for drilling the hole, the project team at Bruce turned to other issues. One problem was how to deal with smaller secondary steam hammers caused by steam bubble formation and collapse in the drain lines. The team members concluded that

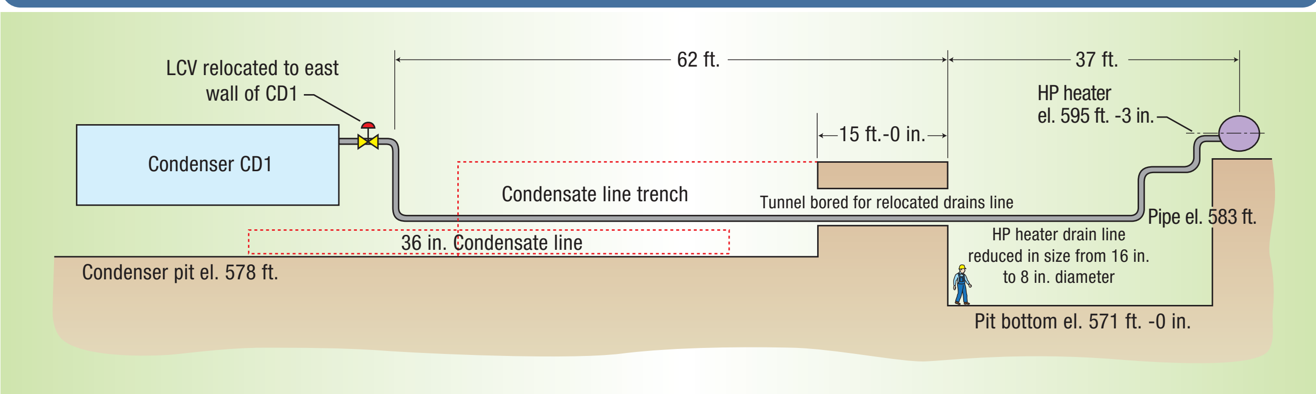
Photo courtesy Bruce Power

Bruce Power

The Bruce Power site on the shores of Lake Huron in Ontario, Canada, is the largest nuclear facility in North America. It covers 2,300 acres, employs 3,700 people and has eight CANDU nuclear reactors, six of which are operating today. When the last two units are brought back on-line, there will be more than 6,200 MW of capacity at this one site.

Bruce has been aggressive about bringing mothballed units back on-line to meet the growing power needs of the province and the company is involved in new nuclear capacity that it being considered for the oil sands in Western Canada.

Figure 2 NEW CONFIGURATION



One of the boring bits. Photo, Bruce Power.

given the new layout, they could go with smaller, shorter lines that were sloped slightly upwards, which should reduce the chances of steam bubble formation. As a backup measure, they also decided to design the lines to withstand steam hammer, just in case.

With the hole drilling and line design issues under control, the team then turned its attention to optimizing the process control system. While moving toward digital everywhere possible to take advantage of the improved performance that technology offers, the team had to make sure that existing analog and safety controls could be integrated into the approach. The team also had to deliver a total turnkey system in four months and install it in 28 days. And just to add a little spice to life, "tuning" the system on line was not allowed. The team had to be able to model the performance, set tuning parameters and walk away, knowing that the system would operate as designed.

To meet these goals, the team adopted a novel approach for managing the project. In a typical command-and-control structure, key communications have to pass up and down the command line. Given the tight time constraints on this project, all three parties agreed to work with each other as equals. This increased the speed of information exchange, key to getting this done in the tight timeframe.

The other major shift from business as usual was that the team decided to carry out what it called "smart utilization of smart equipment." Solenoids and junction boxes were integrated onto the valve assemblies. An interlock was tied in so that if power was lost to the solenoid, the positioner air supply was blocked and the valve actuator used its spring to get the valve to the fail-safe position. The team even used the highway addressable remote transducer (HART) signal inherent in the digital approach to detect the solenoid trip.

And finally, the team set up the digital positioner on the valve to provide a direct signal for valve position and to enable on-line valve diagnostics. This approach uses two-way communication between the control room and the valve for on-line troubleshooting, looking for advance signs of problems that could impact process performance. This allows the plant to move away from preventive maintenance, typical within the industry and toward true predictive maintenance, a more effective way to address valve and process problems.

THE POWER OF DIGITAL TECHNOLOGY

As mentioned , the typical approach in the nuclear industry is to avoid on-line tuning and optimization because of concern that some type of process upset could trip the plant. The team also did not have a lot of time during the outage window to make it right, so team members had to come up with an approach that would allow them to be 99 percent sure that they got the system right before they brought it on-line. Lakeside used modeling software to simulate the process and all the mechanical elements in the loop, right down to the speed of response and flow characteristic of the valves used—another advantage of the digital age and benefit of the integrated turnkey approach taken with this project.

This modeling software was then used to optimize the system's tuning parameters, both during steady state performance and transients associated with start-up and shutdown. They looked at unusual situations, like pump failures and single bank heater operation. The results? The predicted performance agreed almost exactly with what was seen during the actual startup of the heaters.

MORE EFFICIENT, MORE POWER

The tunnels were bored, the old piping system was removed, new piping installed, control system installed and cold commissioning, all in 28 days. The unit ran-up in service as predicted, with no alarms of any kind, to full power. The only operator intervention was switching on the drain pumps. Some minor disturbances were seen that later were corrected with minor control changes. Once these changes were made, the next system start-up went flawlessly.

Since the plant can now run up to full power with the heaters on-line with no risk of water hammer, they are more efficient and generate more power. Overall, a more stable system requires fewer manual interventions and is inherently safer as a result. Since the process fluctuates less, all of the major mechanical components in and around the heaters will last longer, saving the plant on maintenance spending.

The simulation was an important part of the approach, allowing the team to get as much done before the outage as possible to insure that the implementation and startup would go as planned. Other related problems like incorrect valve sizing and control logic problems were identified too, which would not have been found otherwise.

Fully utilizing the power of digital technology coupled with a teamwork approach to project management can yield impressive results. Successful implementation of a project of this scope in seven months would have been impossible without this approach.

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