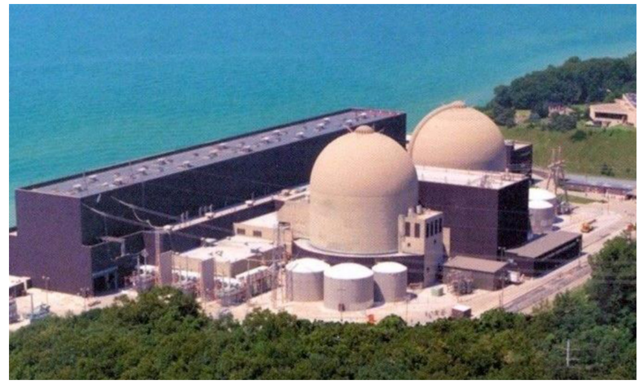

Best Practices in Plant Reliability and Performance

D.C. COOK COMPLETES DIGITAL INSTRUMENTATION AND CONTROL SYSTEMS UPGRADE

"We went from a single failure mode of a real component on the main control board to virtual equivalents on the main console, plus two other computer workstations, so we are now triple-redundant."

— Terry Beilman, a Senior Project Manager on Cook's I&C Team

AMERICAN ELECTRIC POWER

Organization
American Electric Power's Donald C. Cook Nuclear Plant located on Lake Michigan's eastern shoreline in Berrien County, Michigan.

Challenge
I&C engineers needed to upgrade their digital control systems to support its 20-year plant extension.

Solution
Replace existing obsolescent technologies with Curtiss-Wright's digital control system, utilizing the best in class nuclear grade RTP 3000 I/O platform to optimize operations and reduce obsolesce.

Results
The upgraded system now offers significant performance improvements, easier to replace parts, and a triple-redundant operating system.

Owned and operated by American Electric Power, the Donald C. Cook Nuclear Plant is located on 650 acres along Lake Michigan's eastern shoreline in Berrien County, Michigan. At full power, its two thermal units can generate enough electricity for more than 1.5 million homes. When D.C. Cook received a 20-year license extension from the Nuclear Regulatory Commission, its on-site engineering team took a hard look at plant obsolescence issues, with an eye to reducing the cost of system maintenance and extending the viability and stability of the plant's reactor control systems.

Experts on the I&C/Digital Controls Upgrades team determined that the plant's legacy Reactor Controls and Instrumentation (RCI) systems needed to be retired due to reliability reasons and the difficulty in procuring replacement parts for critical components of these systems.

D.C. Cook has seen improved reliability and availability with its new digital controls on many levels, partly due to the extensive redundancy engineered into the wiring, instrumentation, computers, switches, sensors, power supplies, RTP 3000 I/O equipment, and other electronics. As an added benefit, Cook can replace components without taking the power plant online. This modern infrastructure delivers real-time data for controlling every facet of operation, and it also offers more precise methods for adjusting configuration parameters with greater granularity.

DIGITAL CONTROLS WITH MAXIMUM REDUNDANCY

For the new RCI, Curtiss-Wright supplied components for a series of 12 instrumentation racks, or cabinets. The old controls were replaced with new digital components, including power supplies, servers, network switches, and RTP 3000

I/O equipment. They also created backup HMI capabilities for the operators who control and monitor the plant.

"We went from a single failure mode of a real component on the main control board to virtual equivalents on the main console, plus two other computer workstations, so we are now triple-redundant," says Terry Beilman, a Senior Project Manager on Cook's I&C team.

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"Operators see the exact same controllers on their workstations as they do on the main control panel," says Quinn Reynolds, P.E., a Manager with Sargent & Lundy, who served as responsible engineer for the project and continues to oversee all of the engineering and design interfaces. "Thus if the main control board controller fails, they can still interface with critical plant processes from their workstations in the control room. It's a seamless operation."

COLLABORATIVE TRAINING, TESTING, AND STAGING

Beilman and Reynolds worked closely with Curtiss-Wright to produce the design specifications as part of an iterative process. The specs covered every facet of these major lifecycle upgrades to DC Cook's two nuclear units.

In preparation for receiving the new RCI system, Cook built a Digital Control Staging Area (DCSA): a two-story building on the turbine deck, not far from the control rooms. "We unpacked the components and literally re-built the system in the DCSA," Beilman explains. "Then, over a period of months, we checked and rechecked all the test items that were installed on the system. The scope of the RCI project was extremely large. For example, among many other tasks, the RCI required the installation and testing of 18,000 wiring terminations."

RCI CONTROL FUNCTIONS

D. C. Cook's Reactor Controls Instrumentation I&C upgrade included the following control functions:

- Steam Generator Water Level
- Steam Generator PORV
- Pressurizer Pressure Control
- Pressurizer Level Control
- Pressurizer Level Charging Flow Control
- Boric Acid Flow Control
- Primary Water Flow Control
- Steam Dump Control and Main Steam Turbine Bypass Header Pressure
- Feedwater Pump Speed Control
- Turbine Impulse Pressure
- TRef, TRef Lagged
- Upper Containment Narrow Range Pressure Channel 2
- Lower Containment Channel 1 Pressure
- Volume Control Tank Level
- Letdown Heat Exchanger Discharge Pressure
- Letdown Heat Exchanger Discharge Temperature
- Hi Auctioneered Tavg
- Hi Auctioneered Delta T % Power
- Rod Insertion Limits
- Rod Control

Each unit includes a plant simulator—full-sized equivalents that allow operators to train and interface with the control room. While the Curtiss-Wright team was building the new RCI system, the Cook team modeled and ran the software on these plant simulators, constantly conducting and rerunning critical plant procedures to validate the new capabilities. The team performed 14 factory acceptance tests (FATs) for each unit. Each test comprised about 19,000 pages of data.

"We spent a significant amount of time verifying, validating, and making changes to the system to ensure that it met our requirements, and we trained about ten subject matter experts," Beilman says. "Curtiss-Wright was extremely supportive in sharing information and allowing us to engage in the factory acceptance testing process, even though we approached these tests at a level that they probably weren't used to from other projects. FAT testing alone took about nine or ten months per unit."

D.C. COOK COMPLETES DIGITAL INSTRUMENTATION AND CONTROL SYSTEMS UPGRADE

U1 and U2 Systems staged for FAT testing in Curtiss-Wright's Idaho Falls Facility

GOING LIVE WITH END-TO-END DIGITAL CONTROLS

Cook went live with the new digital control systems at Unit 2 in May 2018 and at Unit 1 in May 2019, capping off a multi-year effort to install digital technology throughout the plant. Since then, they have had no issues of consequence. "I think we've only had three or four alarms that required the system manager to respond, and in each case he was able to simply reset a parameter and walk away without actually having to do any repairs," Beilman says. "When you consider the magnitude of these projects, and the significant number of operating loops, components, and terminations, that indicates a remarkably high quality system."

"We can see things in the system that we could never see before—plus we can trend it and match it up with other data," Reynolds adds. "For example, operators and engineers can see the exact component that failed and what its impact is on the plant."

As part of this plant-wide digital upgrade, Cook eliminated more than 30 single points of vulnerability that they identified in the previous systems. Engineers can define which values to maintain for each backup component if the corresponding primary component fails, reducing risk to plant processes. So far, the system has performed so well that Cook has not had to rely on this failsafe. "We haven't had occasion to shift from the primary to the backup, because all the components are working so well," Beilman confirms.

Cook has seen improved reliability and availability with its new digital controls on many levels, partly due to the extensive redundancy engineered into the wiring, instrumentation, computers, switches, sensors, power supplies, RTP 3000 system, and other electronics. For example, previously there was a single power feed to the instrumentation racks. Now there are two feeds, not only to the racks, but also to each component. As an added benefit, Cook can replace components without taking the power plant off-line.

"We have dramatically improved the operation between refueling outages," Reynolds concludes, "and there is much more information available to the system manager and operators through the new digital system."