

Purdue University Moves into the Modern Age with Digital Research Reactor Control System

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— Clive Townsend, Reactor Supervisor, Purdue University

PURDUE UNIVERSITY

Nuclear Engineering

Organization: Purdue University uses the PUR-1 nuclear reactor to educate students, conduct research into nuclear physics, and engage the public on the benefits of nuclear power.

Challenge: Operating since 1962, the PUR-1 reactor began experiencing mechanical and electronic issues. Its aging analog equipment was becoming increasingly burdensome to refurbish.

Solution: Purdue elected to replace the reactor’s analog system with a digital replacement. Curtiss-Wright helped develop and implement the fully digital control and safety system - the first of its kind licensed by the Nuclear Regulatory Commission (NRC.)

Results: The digital system simplifies operation of the reactor, providing advanced capabilities for collecting, analyzing, and archiving data.

When Purdue University received a grant from the United States Department of Energy to decommission the legacy equipment controlling its PUR-1 Research Reactor and replace it with a digital control system, the university took it as an opportunity to launch its educational facilities into the modern age.

“We are trying to attract Millennial engineers who have never lived in a world without smart phones,” says Clive Townsend, Reactor Supervisor at the site. “If I show them vacuum tubes, their attention span is significantly reduced. But if I show them a 150-square-foot video wall with 10 flat-screen TVs, along with modern digital technology that has been engineered for the 21st century, their interest goes up quickly.”

Designed and licensed for operation at 10 kW, the PUR-1 reactor is managed and operated by the Purdue University’s School of Nuclear Engineering. It has been operating almost continuously since the Atomic Energy Commission licensed it in 1962.

Like most of the two dozen nuclear research reactors in the United States,

the PUR-1 has three basic purposes: to educate students who are interested in the field of nuclear engineering, to enable fundamental research into nuclear physics, and to engage the public on the benefits of nuclear power. As Townsend sees it, this fleet of research reactors—and many of the nation’s industrial reactors as well—will need to leverage the benefits of digital technology to further their impact on the green energy supply. Each facility must decide whether to replace old electronics with modern analog counterparts, or develop digital systems that provide similar functionality. Purdue boldly chose the latter.

“This work is definitely groundbreaking,” Townsend says. “And the project was a success. PUR-1 has the first fully digital control and safety system to be licensed by the United States Nuclear Regulatory Commission.”

RESOLVING OPERATIONAL ISSUES WITH THE PUR-1 REACTOR

According to Townsend, PUR-1’s previous instrumentation and electronics had some issues. Noise spikes in



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the startup channel and its associated circuitry caused spurious signals within the period meter, causing intermittent shutdowns. Furthermore, Purdue had only limited capabilities for data acquisition and analytics. Its former control system could not import real-time data, so operators had to glean operational values from paper charts and analog dials. These methods were less precise since they were subject to certain parameters that were beyond their control such as the temperature of the room, time of day, and other factors.

“Our aging electronics got to a point where they were so taxing to use that it would have been a significant challenge to refurbish them,” Townsend admits. “The time was right to implement a digital system. As a research institution, we have an obligation to push the limits of available technology. Ultimately it was a decision of analog versus digital, and we chose digital because it would have a greater impact.”

Curtiss-Wright partnered with Mirion Technologies to help the university complete the digital conversion project. The team was well aware of the historic nature of the facility, and they stepped up to the challenge of replacing analog components with their digital counterparts. Mirion delivered neutron flux monitoring equipment and the reactor protection components. Curtiss-Wright spearheaded the development and implementation of the Reactor Control System Human-Machine Interface, in conjunction with the Reactor Operator Console (ROC) Display Workstation. They used the Scientech R*TIME Display Builder and other display tools to create these software assets. The design implementation took about nine months and the new digital instrumentation and control (I&C) system was installed in parallel with the old system.

“The Curtiss-Wright team was very flexible, even when we asked them to add new functional requirements

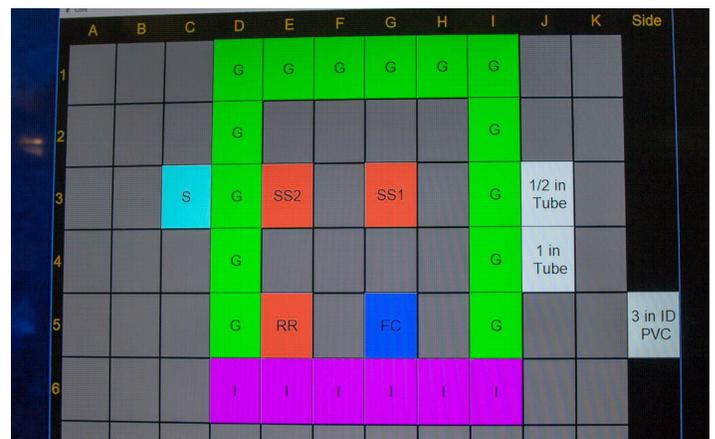
throughout the project,” Townsend says.

The new console features a 150-square-foot video wall that maximizes data display capabilities. The digital control system also includes new data acquisition technology. Analog neutron detector signals are digitized when they reach the instrumentation modules. All control and safety actions are based on calculations and comparisons of these digital values. The detector output and reactor parameters are tracked and stored so that data can be made available to researchers.

The new hardware and software environments were installed side by side with the former Purdue reactor controls, so engineers could test the capabilities and observe the similarities and differences to the system. After Purdue University verified that everything was working correctly, the Nuclear Regulatory Commission sent a team to review the documentation and implementation

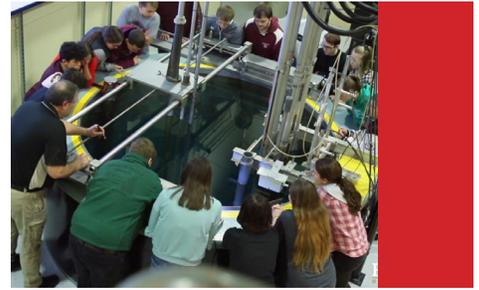


Analog Reactor Core Map



Digital Reactor Core Map

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of the system. With the License Amendment now fully approved, the original console has been replaced with the fully integrated digital control system.

In order to simplify regulatory approvals with the NRC, the team duplicated the analog design of the 1962 reactor control system and safety system. For example, the reactor has the same number of control blades, neutron flux monitoring channels, diversity of parameter indicators, and location of annunciators. The indications for rod height, reactor power, and shim-safety drive selection are similar to the old design. This allowed the NRC licensing officials to focus on the digital implementation without having to revisit the overall design.

RELIABLE OPERATIONS THAT GUIDE EDUCATION AND RESEARCH

The ROC Display Workstation dramatically simplifies the operation of the reactor. For example, it's easier for the operations team to adjust parameters and modify reactor values. A set of display screens allows them to constantly monitor reactor performance. The reactor will be automatically tripped if certain parameters are exceeded.

The new system also includes advanced capabilities for collecting, analyzing, and archiving data. Students can view historical trends about operating parameters, power levels, and other data points, visualized through dynamic

charts and graphs. Data is available through the Purdue University network, allowing students and staff members to observe these analyses from afar, enabling new types of distance learning.

Because the university recently increased the licensed power rating of the PUR-1 reactor from 1 kW to 10 kW steady state power, Curtiss-Wright accommodated this change in the new control system. It can support the higher power level with only a recalibration of the instrumentation and modification of applicable set points.

A SHOWCASE FOR THE NUCLEAR POWER INDUSTRY

Purdue University has a long history of strength in engineering, and its educators recognize a sizable shift in the needs and skillsets required by today's workforce. “We are making a concerted effort to be world leaders in this area, and to embrace technologies that advance the industry and society. Purdue is uniquely positioned to be a nuclear cyber-physical research center focused on the interface of *what we code* and *what we touch*,” Townsend notes.

To that end, the PUR-1 Research Reactor is poised to reinvigorate Purdue's original mission of pursuing fundamental physics research—this time in conjunction with artificial intelligence, cybersecurity, and other advanced software endeavors. As more and more digital components are integrated into

the nation's nuclear fleet, many of these fundamental questions must be revisited.

“The curriculum is much more interesting and accessible to students,” Townsend concludes. “This is the first system of its type to be approved for operational use in the United States, making it a showcase installation for Purdue, for Curtiss-Wright, and for the NRC.”

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