CURTISS-WRIGHT

Khmelnitskyi NPP Implements RadICS Digital Safety System

DIGITAL CONTROL SYSTEM SOLUTIONS

Organization
Khmelnitskyi, a nuclear power plant operating in the Ukraine.

Challenge
Plant-wide upgrades sought to bring plant up to international requirements with an eye for nuclear safety and environmental sustainability.

Solution
Upgrade existing systems using the RadICS platform to increase safety, availability, and long-term operational stability of the plant.

Results
The plant now has a more modern, efficient, and cost-effective digital safety platform.

Curtiss-Wright has partnered with Radics, LLC—an international nuclear engineering company specializing in advanced, customized I&C solutions— to bring the RadICS digital instrumentation platform to the U.S. nuclear power market.

Located in Netishyn, Ukraine, Khmelnitskyi NPP is one of four Ukrainian nuclear power plants owned and operated by the Ukraine's State Enterprise National Nuclear Energy Generating Company, also known as Energoatom. Collectively, these plants provide more than 50 percent of Ukraine's demand for electric energy. Khmelnitskyi NPP maintains two nuclear power units based on the VVER-1000 design, a pressurized water reactor commonly used in Eastern Europe. Unit 1 has been in operation since 1987, with an operational life through 2029. Unit 2 has been in operation since 2004, and has an operational life through 2034.

Radiy has supplied new Engineered Safety Factors Actuation Systems (ESFAS) at Khmelnitskyi Nuclear Power Plant (NPP) based on the RadICS digital safety platform. This digital upgrade was part of a larger plant upgrade program that included replacing in-core monitoring systems, modernizing chemical control systems and condensate polishers, and reconstructing the plant's radiation monitoring system—all with an eye to complying with international requirements for nuclear safety and environmental sustainability. Khmelnitskyi NPP now has a more modern, efficient, and cost-effective digital safety platform.

BRINGING LEGACY SYSTEMS INTO THE MODERN AGE

Addressing aging and obsolescence of nuclear components is a high priority for nuclear power plants around the world. Plants such as Khmelnitskyi NPP have numerous parts that need to be repaired or replaced prior to the end-of-plant life. However, in many cases, the manufacturing firms that provided the original parts are no longer in business or properly certified. Thus the onus is on the nuclear power plant to find safe and reliable sources for replacing these parts—or upgrade to modern equivalents.

Previously, Khmelnitskyi used a Kaskad-2 I&C hardware and software system (also

radICS

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Engineered Safety Feature Actuation Systems at Khmelnitsky NPP

called UKTS), in conjunction with a RTZO-69 switch gear and control gear, I&C panels, and Sapphir-22 measuring convertors. Khmelnitskyi's I&C team embarked on a digital modernization project to improve overall reliability and overcome component obsolescence issues.

Digital safety systems deliver safety improvements that were not available with old analog systems, such as continuous diagnostics, more robust monitoring capabilities, and detailed performance indicators for operations and maintenance staff. These automated capabilities eliminate the need for scheduled online surveillance activities and facilitate condition-based maintenance, boosting the efficiency of the maintenance staff.

"The main purpose of this modernization project was to comply with the latest international standards for nuclear and radiation safety with respect to the plant's I&C systems," says Valentin Samtsov, head of Khmelnitskyi's I&C division. "We wanted to close gaps in existing regulations, safety standards, and rules of radiation safety, as well as eliminate possible defects in our existing I&C systems."

BROADENING THE SCOPE OF THE PROJECT

Khmelnitskyi's comprehensive modernization project included upgrading protection relays, automating electrical controls, establishing remote and automatic control of actuators, enhancing human-machine interfaces, and improving equipment diagnostics.

"We held many technical meetings to identify the equipment requiring modernization," continues Samtsov. "We reviewed all options based on the Complex (Consolidated) Safety Upgrade Program of Ukrainian Power Units of Nuclear Power Plants, including reviewing many regulatory documents and requirements."

Radiy introduced the design concept for the systems to be upgraded; Khmelnitsky NPP specialists were invited to attend feature acceptance testing (FAT) sessions for similar digital safety systems recently implemented at for Rivne, another Ukrainian nuclear power plant, to examine the system in action. The digital safety objectives included the ability to perform a safety-level upgrade that enables all power units to meet modern national safety standards, implementation of IAEA recommendations, replacement of essential safety equipment that has reached the end of its service life, and implementation of corrective measures for preventing accidents and spurious actuations.

WORKING WITH AN EXPERIENCED GUIDE TO ACCELERATE THE IMPLEMENTATION

Radiy spearheaded the implementation of this new system in conjunction with the Khmelnitskyi NPP team. They helped

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"Remote diagnostics enables operators to respond promptly to changes of technological parameters and to minimize repair and fault correction time."

— Valentin Samtsov, Head of Khmelnitskyi's I&C division

identify issues and formulate solutions based on cumulative experience gained at Rivne and other digital safety system projects. As issues arose, Khmelnitskyi NPP received prompt assistance from Radiy personnel.

During 2019, Khmelnitskyi NPP Unit 1 installed two new ESFAS, which protect, block, and monitor the automated operation of actuators, while also executing automatic process control and manual remote control of actuators. These ESFAS systems include functions that are necessary for NPP safety, such as information and data acquisition; signal conditioning and control of safety signals, detectors, and sensors; and full-scope systems diagnostics.

Two local companies assisted with the installation, as supervised by Radiy. According to Mr. Samtsov, the I&C team encountered some integration challenges, but all of them were successfully overcome by the joint team. Samtsov describes the engagement as a "productive collaboration" aimed at achieving the plant's larger goals. "Radiy specialists provided comprehensive assistance while developing technical specifications. They developed rational proposals for improving the functionality of the future system," he adds.

STANDARDIZING ON A MODERN ARCHITECTURE

The RadICS platform includes Field Programmable Gate Array (FPGA) chips as computational engines, highly regarded for their ability to support both discrete and analog input/output (I/O) modules and deliver responses in as fast as 10 milliseconds. These general-purpose building blocks can be easily configured according to the needs of each project and system.

The new equipment uses a smaller equipment footprint than the analog equipment it has replaced while adding significant more diagnostic and monitoring capabilities. Generally, the RadICS system fits into a third of the space of older existing analog systems, simplifying the modification. In addition, the modular RadICS system is much simpler with only 10 module types, as opposed to 34 module types in the old UKTS safety system.

Fiber optic communication and control lines were installed to replace hundreds of kilometers of electrical cables. "The use of fiber optics significantly reduces the use of expensive copper cable connections," Samtsov explains. "Fiber optic communication lines are capable of higher noise immunity, and they can transmit both discrete and analog information. The entire package of control commands is generated in one cable." These digital links also simplify some aspects of plant safety, since having fewer copper lines reduces the fire load in the power unit cable structures.

COMPLYING WITH IEC REQUIREMENTS

Khmelnitskyi's digital safety systems meet the following important safety standards from the IEC/IAEA: IEC 61508, IEC 61511, IEC 62061, ISO 13849-1. Collectively, they ensure robust operation in: reliability; single failure; redundancy; independence; common cause failure protection; technical diagnostics and monitoring availability; functional quality; functional stability; resistance to power parameter variations; electromagnetic compatibility and emission restriction; human error prevention; unauthorized access protection; and cybersecurity.

COLLECTING OPERATIONAL EXPERIENCE

Currently, the new ESFAS systems are operating in trial mode as the staff accumulates operational experience. "The digital safety environment has been stable, and there have been no mishaps, failures, or false shutdowns," Samtsov says.

The new RadICS safety platform continuously monitors the operation of the plant and responds to any issues that might compromise safety. It performs logic computations to create control commands, and converts control commands to output signals that are then applied to field actuators. Internal diagnostics performed by the system warn operators of potential system failures. These automated capabilities

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eliminate the need for scheduling online surveillance activities and facilitate condition-based maintenance, boosting the efficiency of the maintenance staff.

The human-machine interface allows operators to easily monitor all on-line diagnostic functions and perform surveillance testing of the plant's safety systems; this software has also automated key processes and procedures. The user-friendly system design allows engineers to spend less time on technical maintenance.

"The installation of new I&C systems considerably reduced the personnel load—partly because we have fewer cabinets, but also because the remote diagnostics enables operators to respond promptly to changes of technological parameters and to minimize repair and fault correction time," Samtsov confirms.

INTEGRATED DIGITAL SAFETY SOLUTIONS FROM CURTISS-WRIGHT

Based in part on Radiy's successful implementations at Khmelnitskyi NPP and other sites around the world, RadICS has become an essential component in a new set of digital safety systems that Curtiss-Wright offers to the U.S. market. As a systems integrator, Curtiss-Wright brings together the best available hardware and software components for each project. The RadICS platform forms the basis of Curtiss-Wright's NRC-approved Digital Safety System, a functionally and technologically diverse replacement for analog and digital safety-related systems at nuclear power plants throughout the United States. The July 31, 2019 U.S. Nuclear Regulatory Commission approval of the RadICS I&C platform for use in safety-related systems in nuclear power plants paves the way for this technology at U.S. nuclear power plants.