

Delivering the Nuclear Promise Top Innovative Practice



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Rod Control and Rod Drive Power Supply Digital Upgrade Westinghouse CE Vendor Award Winner¹ 2023 Top Innovative Practice Winner

Summary

Over the past several years Palo Verde Generating Station (PVGS) has experienced obsolescence, equipment reliability, and operational impacts due to aging analog non-safety control systems. The Strategic Modernization Program (SMP) was initiated to drive replacement and digitization of these antiquated control systems over several individual project phases. The Ovation™ Distributed Control System (DCS)² was selected as the common platform for all phases, allowing for greater accessibility, standardization, and efficiency throughout the life cycle of the program.

The second phase of SMP spearheaded the replacement of both the Control Element Drive Mechanism Control System (CEDMCS) and the Rod Drive Power Supply (RDPS)³. These systems were upgraded to the Westinghouse Advanced Rod Control Hybrid (ARCH) and Next Generation Rod Drive Power Supply. The replacement of the original Combustion Engineering rod control design was prioritized in Phase II due to an increasing number of consequential plant events including dropped rods and reactor trips.

Innovation

The Westinghouse ARCH was adapted from the Digital Rod Control System platform used for new plant installations, such as the AP1000™. The system was designed with digital technologies to eliminate all single point vulnerabilities that lead to dropped rods. In addition, ARCH provides automatic capture of rod traces and performs continuous monitoring of control element drive motors to improve predictions of coil winding degradation. Other notable system features include the reduction of common failure modes, improved maintainability, and more effective troubleshooting capabilities. Advanced automation was introduced at PVGS to reduce common operator task completion and leverage the existing Ovation™ control logic to support automatic movements. The automation features were designed with direct input from plant operators to reduce repetitive rod control tasks, that include:

- Automated Reactivity Maneuver Plans (Game Plan) - Reactor Engineering prepares a file for pre-planned Reactivity Maneuver Plans containing a list of Control Element Assemblies (CEAs) and positions for each

¹ Winning entries of from NEI's Top Innovative Practices (TIP) awards are republished as DNP Efficiency Opportunities to ensure the broadest possible dissemination of these operating plant innovations.

² <https://www.emerson.com/en-us/automation/control-and-safety-systems/distributed-control-systems-dcs/ovation-distributed-control-system>

³ [https://www.westinghousenuclear.com/Portals/0/operating%20plant%20services/replacement%20parts/RDPS%20Flysheet%20REV.2_%20\(002\).pdf](https://www.westinghousenuclear.com/Portals/0/operating%20plant%20services/replacement%20parts/RDPS%20Flysheet%20REV.2_%20(002).pdf)

CEA to be moved to and from. This file is uploaded into an Ovation™ server, where it can be transferred in the new Reactivity Maneuver Plans Ovation™ screens. The CEA steps pre-identified by Reactor Engineering will populate onto an Ovation™ screen, and operators can select to perform the rod movements per the Reactivity Maneuver Plan directly from this screen. The Reactivity Maneuver Plans screen is used to move the selected CEAs on a single line of the Reactivity Maneuver Plan when an operator presses the start button.

- Automated CEA Operability Checks - Operators can navigate to a dedicated CEA operability Ovation™ display and select groups of CEAs. From the selected groups of CEAs, a start button on the screen can be pressed. Each selected CEA is then inserted seven steps in and withdrawn seven steps out, one at a time in the sequence selected. This automation is intended to be performed to meet the requirements of Surveillance Test Procedure 40ST-9SF01, "CEA Operability Checks." Once the automated CEA operability check is run, Operations personnel observe the CEA movements and obtain a printout verifying all CEAs moved correctly.
- Automated CEA Dress Out Capability – Operators can navigate to the Ovation™ dress out display screen and select a group of CEAs to call for movement of the rods from their current position to Upper Electrical Limit (UEL) (150 inches) or UEL-1 (149.25 inches). Once an operator initiates the dress out function from the Ovation™ display, the preselected group of rods will automatically move from their existing position to the selected position (either UEL, or UEL-1) one CEA at a time. Movement of CEAs between the UEL and UEL-1 positions is periodically performed at power, to prevent fuel assembly guide tube mechanical wear, which may otherwise occur due to flow-induced CEA vibrations.
- Automated Rod Motion to Reach an Input Target Position (Target Motion) – Operators enter a desired rod position (in inches) for an individual rod, or a group of rods. ARCH automatically moves the rods to the target position when operators press the start button.

The Next Generation RDPS, which consists of two Motor-Generator (MG) sets and two newly designed control cabinets, provides the significant advantage of allowing one MG to be offline for maintenance while the other is powering ARCH. Each MG is sized to carry the maximum ARCH electrical load; this redundancy allows much more flexibility and provides single fault tolerance above that of the original system. Key system parameters are communicated to the Ovation™ DCS via datalinks providing enhanced monitoring capabilities. Additionally, the new system provides a significant upgrade in control and ease of maintenance.

Background

The vision for the SMP was born in 2016 to restore control system reliability across various plant systems at Palo Verde in an integrated and strategic manner. A system assessment was performed by an expert cross-functional panel in 2017 to prioritize system replacement considering three criteria: the degree of obsolescence, impact of system failures and the potential to add system improvements during upgrade. The output of this assessment was the initial phasing structure and selection of a common DCS for the program. The early vision for SMP allowed PVGS to establish common system requirements and perform a "proof of concept" installation during Phase I on the Liquid Radwaste and Boric Acid Concentrator systems. Phase I also included common hardware and the Ovation™ backbone for future phases. Ultimately, this structure allowed the team to react to changing plant priorities and accelerate rod control into Phase II as a fast-tracked project and resolve significant plant issues in a timely manner. The remaining systems and phases will be managed and upgraded over the next 10+ years to meet plant reliability needs.

Safety

The ARCH and Next Generation RDPS installed at Palo Verde have positively impacted margin to safety as plant components are monitored in real time and alarms are provided to operations when parameters exceed given

thresholds. This also reduces walkdowns of the equipment minimizing exposure of personnel to potential hazards.

The legacy CEDMCS system had exceptionally large Power Switch Assemblies (PSAs) containing power electronics that weighed approximately four hundred pounds and required a special lifting rig to remove and replace. The new ARCH power electronic Coil Power Management Drawers (CPMDs) weigh just forty pounds, can be removed by a single person, and are much safer for employees to replace.

Cost Savings

This digital technology allows for diagnostics to be run on the entire system in an expeditious manner, facilitating prompt identification of issues. The redundancies in the system allow the repair or replacement of components while the unit is online, eliminating the need to reduce power. The most significant cost savings are realized from the prevention of rod drops and reactor trips. Preventing a reactor trip will save at least \$2,000,000 per occurrence. Situations requiring complex troubleshooting and restoration of legacy systems could incur additional costs that could be avoided by the digital upgrades. Prior to the ARCH upgrade, outage calibrations, coil trace reviews and troubleshooting of the CEDMCS system required approximately 450 person-hours on average from the maintenance and engineering team. This equates to \$45,000 savings in each future outage and allows these personnel to support other important tasks during high resource demand windows.

Productivity/Efficiency

The ARCH system provides real time capture and verification of all rod steps, eliminating the need to establish modification packages to monitor potential issues in the Control Element Drive Mechanisms. The digital system provides advanced monitoring of the latch engagement glitch to confirm proper rod movement. In the event a rod step does not complete the demanded step, double hold is activated to prevent a dropped rod and an Urgent Alarm is initiated, placing the system on hold. No rod movements can occur while an Urgent Alarm is active, further preventing inadvertent dropped rods. Detailed alarm logging provides improved troubleshooting in resolving issues and restoring system operability.

The RDPS replaces aging and high maintenance rotating machinery with a modern design. This design includes advanced diagnostic capabilities using additional sensing equipment. The modern and easily replaceable components allow simpler and quicker actions to restore system operability in the case of a problem. The RDPS was sized to continue normal operation of the rod control system via a single MG providing system reliability, redundancy, and the capability to perform maintenance activities online.

Operations feedback from Unit 3 startup following the ARCH installation identified time savings during startup due to the addition of Automated Target Motion and Automated Dress Out features. As operations procedures are refined, critical path time savings should improve in future startups.

Transferability

The ARCH design is the new standard for digital rod control upgrades across the Westinghouse and Combustion Engineering fleets. This will provide a standard platform, with a large Ovation™ installation base, facilitating standard operation, training, and spare parts inventory. ARCH has been installed at St. Lucie Unit 1 and 2 and Palo Verde Unit 3, and is scheduled for installation at Palo Verde Units 1 and 2.

Likewise, the RDPS design is the new standard design for the Westinghouse and Combustion Engineering fleets. Two different size cabinets exist to account for the difference between the Westinghouse and Combustion Engineering plants, but the components, design, and operation are consistent. The RDPS has been installed at Palo Verde Unit 3 and is scheduled for installation at Palo Verde Units 1 and 2 and at Krško in Slovenia.

Team Members

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Additional Information

Figure 1 – Palo Verde Unit 3 ARCH Installation



Figure 2 – Palo Verde Unit 3 Rod Drive Power Supply Cabinets



Figure 3 – Palo Verde Unit 3 Rod Control Operations Display

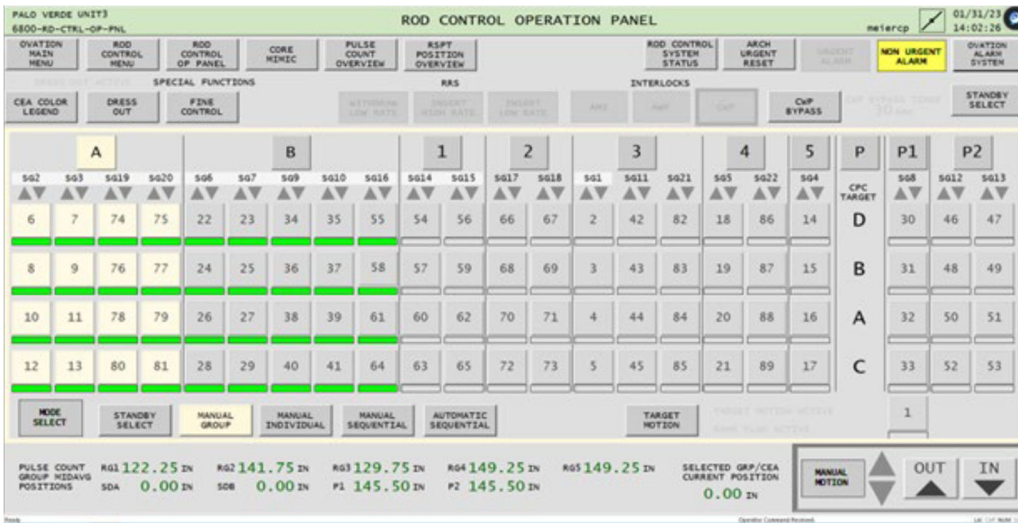


Figure 4 – Palo Verde Unit 3 Rod Drive Power Supply Overview

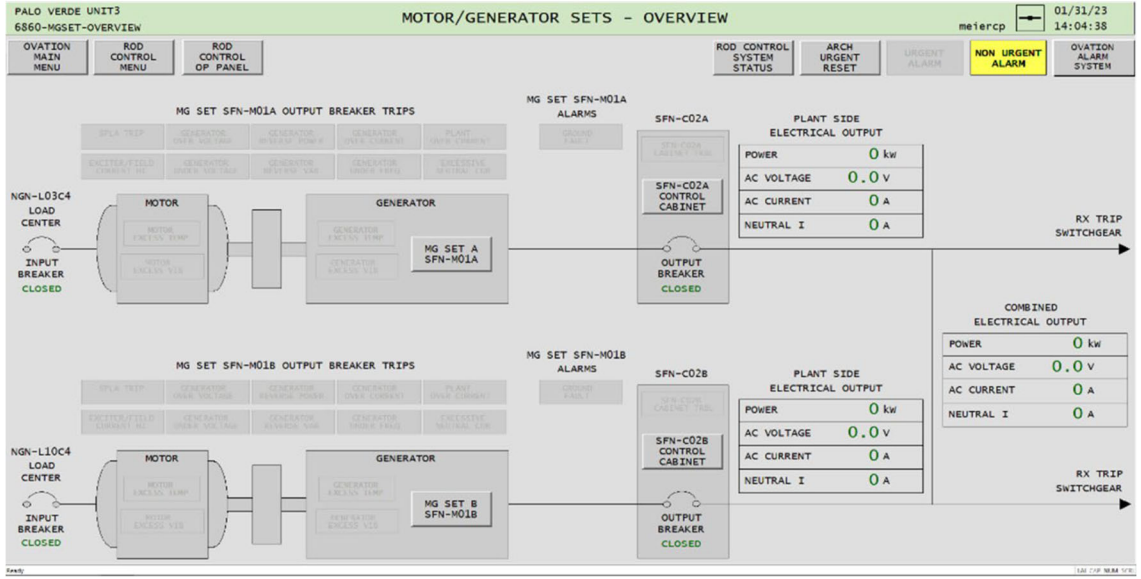


Figure 5 – Westinghouse Current Profile Viewer

