ADVANCED ROD CONTROL HYBRID

ROD CONTROL POWER CABINET REPLACEMENT CONTROL SYSTEM
BACKGROUND

The Westinghouse Solid State Rod Control System (SSRCS) has been in operation at many plants for over 30 years. This system has been very reliable but obsolescence concerns are increasing and personnel experience for the analog control system is difficult to maintain in the modern, digital world. The system also has limited diagnostics and can be time-consuming to troubleshoot, increasing downtime.

For new plant applications, Westinghouse has deployed the Digital Rod Control System (DRCS) to twenty new plants to-date, which are in various stages of startup. While possible to replace the Westinghouse SSRCS with a complete DRCS, this is a challenging single outage installation, and may be a higher risk proposition relative to outage schedule.

To this end, Westinghouse has developed a drop-in replacement for the existing SSRCS power cabinet analog control card chassis that leverages the features and functions of the DRCS, while maintaining the cabinets, system architecture and power electronics. This new hybrid of a digital control system and existing power electronics provides a simplified path forward from analog to digital control. This system is the Westinghouse Advanced Rod Control Hybrid.

SYSTEM DESCRIPTION

Westinghouse Advanced Rod Control Hybrid is Westinghouse's third generation digital rod control system that incorporates over twenty years of digital rod control experience – from the Microprocessor Rod Control System (MRCS) installed in Sizewell B to the new generation of AP1000® plant and APR1400 DRCS installations.

At its base installation, the system consists of an electronics control assembly that takes the place of the existing analog control cards and replaces the Phase Transformer network. This new system reduces the total card count from 20 total cards (seven types) per power cabinet to nine total active control cards (three types) and one built in backplane extender card. These three standard cards will be used across all systems utilizing Westinghouse Advanced Rod Control Hybrid, including Combustion Engineering (CE) plants, allowing for synergies in the fleet-wide spare part program. The existing -24VDC power supplies are no longer required, and the auctioneering diode assembly is replaced.

The new cards are industrial grade, Institute of Electrical and Electronics Engineers (IEEE)-based, IPC-A-610 Class 2 printed circuit cards, with modern components based around an industry standard, industrial safety grade, ARM Real-Time microcontroller.

Figure 1-1 – Westinghouse Advanced Rod Control Hybrid Microcontroller Card – Current Regulating Controller Card (CRC)
Because the system is microcontroller-based, coil timing is moved from the logic cabinet into the power cabinet, removing the need for current order surveillance. A simplified, single-fault tolerant control scheme is used that works in conjunction with the Ovation™ Logic Cabinet Rod Control Upgrade. This will re-use existing cabinet wiring so installation will not require additional hardwired signals to be run from the logic cabinet to the power cabinets. All that is required is a single fiber-optic connection to each new electronic control assembly.

TRUE DOUBLE HOLD

Each set of cards is capable of controlling up to four SCR bridges. As such, using this hybrid, the single movable gripper silicon controlled rectifier (SCR) bridge and support circuitry can be replaced with three individual bridges, which will allow for true double hold. This removes the chance of a single fault on the stationary gripper causing a rod drop or slip. This also removes the need for the DC hold cabinet, as holding can be maintained on the movable gripper while the stationary gripper is de-energized.

Additionally, the existing single set of phase transformers is replaced with two redundant, simplified phase transformers. This removes another single fault and allows the movable gripper to retain phase crossing and subsequently holding in the event of complete or partial failure of stationary gripper power.

CONTROL AND DIAGNOSTICS

With the capability of a localized microcontroller, cabinet parameters are continuously monitored and displayed on an Ovation workstation. This includes, but not limited to:

- Detailed alarm information
- Coil current and voltage
- Cabinet temperature
- Calculated holding gripper temperature

Advanced maintenance modes are also available for troubleshooting and testing, including the ability to exercise all signals and system logic/software without M-G set power and loads.

Figure 1-4 and Figure 1-5 show sample system status displays. Ovation displays can be tailored to the customer’s needs and plant specific Human Factored Engineering (HFE) programs.

Ethernet communication enables setpoint modifications to be accomplished via soft display.

Single rod motion is coordinated via soft display, and existing control room lift disconnect switches can be removed or abandoned in place.
CURRENT PROFILE CAPTURE

Westinghouse Advanced Rod Control Hybrid captures current profiles for every step the system takes, and transmits them to a computer for archival in a database. This database can be accessed via the Westinghouse Current Profile Viewer tool, shown in Figure 1-6.

Troubleshooting is simplified by viewing the actual trace that caused the alarm. The trace is retrieved by group, date and time, and eliminates the need to attempt to recreate the condition with a recorder attached, which may be difficult for intermittent error conditions.

Profile data can be archived for future predictive analysis of Control Rod Drive Mechanism (CRDM) operation.

INSTALLATION OPTIONS

Beyond the base system installation, additional power cabinet components such as fuses, resistors and terminal blocks can be upgraded as needed/desired with the modern equivalents used in the DRCS. This flexible approach will allow long-term system upkeep that is consistent with the utilities operational, maintenance and financial strategies.

BENEFITS OVERVIEW

- All timing is determined by the microcontroller digitally; there is no phase shift network required. This drives less hardware associated with phase cross detection.
- Reliability of modern components, and modern manufacturing processes.
- Enhanced diagnostics capabilities.
- Distributed microcontroller architecture enables low-level fault detection and reporting.
- Redundant features and fault detection/recovery features prevent dropping of rods due to single failures in power circuitry or control electronics.
- All printed circuit cards are “hot swappable.”
- Special CRDM individual coil exercise feature removes “crud” buildup upon operator demand.
- The power cabinet monitors and analyzes the current flow to the CRDM coils to confirm that the CRDM grippers operate during rod motion. This confirms that one CRDM gripper latches prior to the other gripper unlatching during rod motion, preventing dropped rods due to sluggish CRDM operation.
- Computer communications between the power cabinets and the logic cabinet support remote diagnostics, maintenance and adjustments to the rod control system.
- The system provides coil current traces – capturing, monitoring and saving for future reference. Misstep or alarm conditions are captured without trying to recreate the condition with additional steps.
- Standard interface to plant data network (Ovation) system is used.
- Single rod motion using soft control.
- Eliminates Termi-point terminations from the card cage, and associated preventative maintenance inspections.