Scram Time Testing Upgrade at a U.S. Nuclear Power Plant

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Organization: A single-unit BWR plant in the Midwestern United States

Challenge: Upgrade the scram time system as part of a larger plant modernization project

Solution: Curtiss-Wright's implementation of a new Control Rod Scram Testing application

Results: End-to-end data tracking with automated calculations significantly reduce testing times while minimizing opportunities for human error and improving worker productivity

Scram time testing is a crucial safety procedure performed at all nuclear power plants. A scram event is a rapid shutdown of the reactor typically initiated by the reactor protection system (RPS) in response to an abnormal condition. By accurately measuring and analyzing the scram time, plant operators and regulators can verify that the RPS and other safety systems are operating within specified limits, contributing to the safe and reliable operation of the plant.

To upgrade the scram time system at a single-unit BWR nuclear power plant in the Midwestern United States, Curtiss-Wright implemented a new Control Rod Scram Timing (CRST) application. The implementation was part of a larger modernization project that included a new plant process computer (PPC) system, transient timing system, and RTP 3000 data acquisition system. These systems acquire data for monitoring control rod positions, scram timing, and rod timing movements.

Scram Time Testing in Context

Control rods are long, slender metal tubes inserted into the reactor core to control the rate of the nuclear fission reaction. They are used to start up and shut down the reactor, and to maintain the reactor at a desired power level. Control rods are also used to respond to abnormal conditions, such as a loss of coolant or a power surge.

Scram timing refers to how quickly the control rods can move from one position to the next. By quickly inserting the control rods into the reactor core, operators can shut down the reactor and prevent a nuclear accident. Curtiss-Wright uses the CRST software to mimic these events during scram time testing scenarios.

This particular BWR plant has approximately 150 rods, monitored by sensors that pulse to record movements. Pulse events are acquired by the transient timing system within 10 milliseconds. Pulses are timestamped by the RTP Gear at a 1 millisecond accuracy which is then collected and analyzed by the R*TIME Plant Process Computer. The CRST system can pick up these pulses for one rod or the entire reactor core to verify scram timing requirements. Digital inputs associated with each rod allow the software to calculate the sequence of events to determine if the plant is meeting its scram time requirements.

Like many nuclear power stations, the plant uses Curtiss-Wright's R*TIME software platform to acquire data from plant sensors and other computer

systems. R*TIME includes functions for data acquisition, data display, and data processing. A data historian records all data inputs and outputs.

"Plant operators must be able to stop the reaction in a certain amount of time, per regulatory requirements," explains Jessie Lilya, a senior systems engineer on Curtiss-Wright's CRST implementation team. "The CRST software records these movements or 'pulses' in milliseconds, allowing them to react quickly. Data is collected through an RTP 3000 task system. R*TIME interfaces with that system and calculates the scram timing."

On Schedule During the Pandemic

The implementation of the PPC, transient timing system, and CRST application took place during the height of the COVID pandemic. Despite the associated constraints that this imposed, the engineering team was able to keep the project on schedule. Each component was subjected to rigorous factory, site, and operational tests to ensure that it meets or exceeds the plant's requirements. Curtiss-Wright's integration team configured the hardware and software; they also created a new human-machine interface (HMI) that allows plant personnel to display the data via charts, graphs, tables, and reports.

After the initial configuration, they shipped the equipment to the plant, where the on-site team made the final connections and conducted factory acceptance testing to verify that everything was properly configured, tested, and documented.

When it came time to install the new CRST software during a plant outage, Lilya and other members of the engineering team brought up the new system six hours faster than expected, allowing the plant to maintain its tight outage schedule.

Accelerating the Project with Automatic Testing

As part of the implementation, the Curtiss-Wright team established interfaces to hundreds of data points. To confirm that these points were properly developed and configured, they ran all pertinent plant systems through multiple testing scenarios—from testing a single control rod to testing all the control rods in the reactor core.

Curtiss-Wright used its Versatile Test System to accelerate the testing cycle. Using a robot framework, this system manages end-to-end testing from input terminals to output terminals and can act as an emulator for plant systems. By recording and archiving pass/fail data in complete test reports, the system reduces the opportunity for human error and dramatically improves productivity.

For the PPC refresh and rod SCRAM timing emulation, the team tested 425 Points (both analog and digital) in just four hours, including the data acquisition software and all new hardware components. The test system automatically generated all documentation and acceptance criteria.

"Large projects such as these require the testing of hundreds of data points, which can extend implementation times and increase burnout for plant personnel," Lilya notes. "Our automated test system allowed us to test multiple test cases in a couple of hours."

Assessing Results and Outcomes

By monitoring and recording scram time data, CRST software applications can help operators and engineers identify and address any problems with the CRDS or other plant systems that could affect the ability of the reactor to be safely shut down.

This BWR plant is on a two-year outage cycle. Scram time testing is performed on all rods when the plant comes up from an outage; additional testing is performed year-round on selective rods. Plant operators use the CRST application to monitor scram timing of individual control rods and to identify rods that are not performing as expected. Engineers use the software to identify trends in scram timing data that could indicate a potential problem, while plant managers use it to track performance and identify areas of improvement. "With this new system, plant personnel can track data from end to end—from where it comes into the system clear out to the log."

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