Nuclear Services/Engineering Services

Subcritical Physics Testing with Subcritical Rod Worth Measurement

Background

Low-power physics testing (LPPT), which is performed before cycle commencement to allow the reactor core to operate as designed, is included in prudent reactor operation. Essential elements of the LPPT program are the measurement of total rod worth, isothermal temperature coefficient (ITC) and critical boron concentration (CBC). Subcritical rod worth measurement (SRWM™), whereby LPPT evolves to subcritical physics testing (SPT), is the next advancement in Westinghouse leading-edge technology. From dilution to rod swap to Dynamic Rod Worth Measurement (DRWM™), Westinghouse has once again redefined the industry standard.

Description

Approved by the U.S. Nuclear Regulatory Commission, the SPT with SRWM methodology facilitates quick, accurate and safe measurement of all physics test parameters necessary to demonstrate that the as-built core and the nuclear design model of the core are consistent.

The SRWM Process

During testing, control rods are withdrawn in the manner typical in preparing for Rod Drop Time Measurement (RDTM). During rod withdrawal from all-rods-in to all-rods-out, SRWM requires approximately 20 statepoints (i.e., hold points) where source range count rate and reactor coolant system (RCS) temperature data are collected. The statepoint sequence can be modified as desired by the customer to allow for simultaneous SRWM and other Mode 3 data collection (e.g., rod position indication).

Upon reaching the all-rods-out condition, the SRWM data analysis system calculates total control rod worth and CBC from the data collected at each statepoint. Following total control rod worth and CBC results evaluation, an ITC measurement is performed by reducing or increasing RCS temperature by approximately 6 degrees and determining the corresponding change in reactivity. This determination is made using the relationship between changes in reactivity and source range response measured during SRWM. After completion of the ITC measurement, the plant is ready to complete RDTM.

SPT with SRWM is a fast and easy way to verify the loaded core to be consistent with the reload design and safety analysis by measuring all required physics test parameters (total control rod worth, ITC and CBC).

Benefits

Performing SPT with SRWM reduces the time required to complete physics testing and the approach to criticality.

- SRWM requires only one to two hours of data collection during the rod withdrawal preceding RDTM.
- SPT with SRWM allows for a normal reactor startup (i.e., pull to critical) rather than a controlled dilution to criticality.

SPT with SRWM may completely remove physics testing from the outage critical path if RDTM is not a critical path activity. SPT with SRWM also eliminates several traditional LPPT activities including the following:

- Reactor exponential test, nuclear heat determination and boron endpoint maneuver
- Power range detector removal from and return to service
- Control rod speed adjustments

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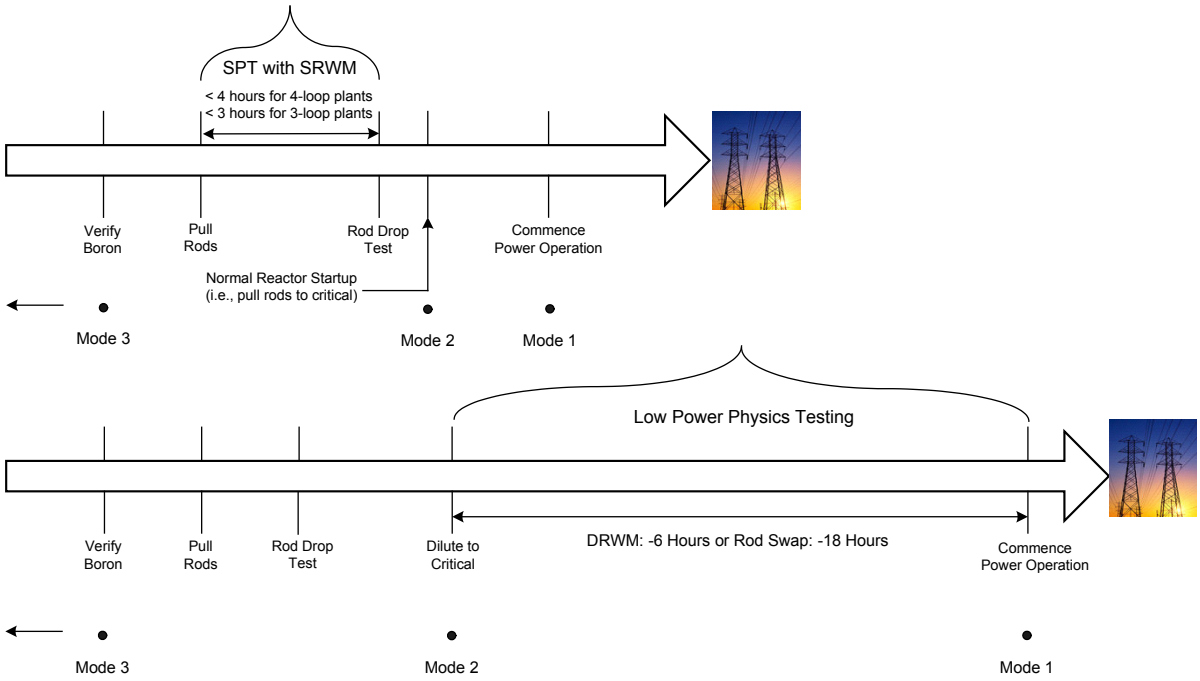

Normal LPPT is a direct barrier to plant start-up. Westinghouse has developed SPT with SRWM, which is an advanced methodology that safely and accurately measures total control rod worth, ITC and CBC at subcritical conditions. As a result, physics testing is no longer a barrier to plant start-up, putting the customer back on the grid faster than ever before.

- The result is less outage time and more time at power. A comparison of the SPT and traditional LPPT evolutions is depicted in the illustration.

In addition to critical path time savings, SPT with SRWM provides the following reactivity management benefits:

- SPT is performed subcritically (Mode 3), greatly reducing the consequences of any adverse reactivity event.
- SRWM does not require any infrequently performed, complicated or time-sensitive rod maneuvers (e.g., bank exchanges, continuous dynamic insertions).
- Unlike existing physics testing methods, SPT with SRWM will not remove an excore detector from service. This allows all nuclear instrumentation and associated trip functions to be operable during physics testing.
- Plant startup can be guided by normal operating procedures as opposed to an infrequently performed dilution to criticality.

In summary, SRWM offers the following benefits:

- Reduces costs by completing testing more quickly than traditional LPPT methods do
- Completes testing in one to two additional hours, typically, in combination with other required tests, such as RDTM, or during the rod withdrawal prior to the approach to critical
- Completes testing off outage critical path in some cases
- Improves reactivity management
- Performs physics testing in Mode 3 with the reactor in a subcritical condition
- Enables all excore detectors to remain in service during testing
- Minimizes the burden on operators due to a simpler test procedure

Experience

- As of spring 2012, SPT with SRWM has been performed 54 times at 10 U.S. stations.
- SPT with SRWM is consistently completed in conjunction with RDTM in less than four hours, thus adding between one and two hours to the total startup duration with no Mode 2 LPPT program.

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