

# DRWM - Dynamic Rod Worth Measurement with RhoPRO™ Reactivity Computer

## Background

Low power physics testing (LPPT) is performed after each refueling to ensure verification of control rod worths prior to returning to full power. The Westinghouse Dynamic Rod Worth Measurement (DRWM™) technique is a Pressurized Water Reactor (PWR) technology designed to accurately and quickly measure control rod worths and reduces the time needed to return to power compared to other methods such as the rod swap technique.

## Description

The Westinghouse DRWM technique is a U.S. Nuclear Regulatory Commission (NRC) approved method to quickly and accurately measure rod worths prior to ascension to full power. To perform the measurement, each bank of control rods is individually inserted and removed from the reactor core in a continuous motion at the maximum rod stepping speed. This requires approximately 7 minutes per rod bank. After each bank is removed from the core, the flux is allowed to recover to the initial starting level. This requires an additional 6 minutes. During the time for flux recovery, data processing is performed by the Westinghouse RhoPRO™ reactivity computing equipment to obtain the total bank worth and the integral worth as a function of bank position. Each bank of rods can be measured in less than 15 minutes. The nine banks in a large Westinghouse four-loop PWR can be measured in about 2 hours.

The current Westinghouse DRWM technique uses an Intermediate Range (IR) channel for monitoring instead of a Power Range (PR) channel used in the older DRWM version. This reduces the possibility of a reactor trip resulting from a Power Range channel being out of service. Additional benefits arise from simplicity in IR connections and reduced I&C personnel support needed. Current users of DRWM will experience minimal transition efforts, since the enhancements build off of the existing DRWM methodology.

The Westinghouse RhoPRO™ reactivity computing equipment and its supporting software have been specifically designed to support data acquisition and analysis with DRWM using the Intermediate Range channel. The menu-driven system minimizes training, set-up time, and data processing. The RhoPRO™ reactivity computing equipment enhances equipment reliability and eliminates replacement parts obsolescence issues with the Westinghouse Advanced Digital Reactivity Computer (ADRC). The equipment size is greatly reduced, allowing for greater flexibility in its placement and permitting better coordination with plant operations in the control room.

The connection of the monitoring equipment requires a minimal set of connections to the plant I&C, significantly reduced from the previous version.

For the application of the DRWM methodology, Westinghouse provides:

- A sample procedure for performing the complete low-power physics testing with DRWM measurements
- Support in preparing a test procedure specifically for the plant
- Westinghouse personnel on-site to assist plant personnel during the performance of the DRWM testing
- Training in both DRWM and in the calibration and use of the RhoPRO™ reactivity computing equipment.

The necessary corrections to the point-kinetics model in the reactivity computer to account for dynamic and static spatial effects are also provided along with a set of pre-test predictions for control rod worths. A post-test evaluation of the results is also provided.

The Westinghouse RhoPRO™ reactivity computing equipment can either be rented or purchased. After initial application for subsequent start-ups, plant operators can perform the measurements or Westinghouse can provide qualified reactor engineers on-site to perform the measurements. The analytical information required can be obtained from Westinghouse or it

can be generated by the plant operator through a technology transfer agreement and license.

## Benefits

DRWM with the RhoPRO™ reactivity computing equipment is a fast and accurate way to measure control rod worths.

- DRWM reduces the time from when the plant starts to go critical until the plant is turned over to the Operations to approximately 8 hours
  - Saves an average of approximately 10 hours of critical path time compared to rod swap techniques
  - Saves another 5 hours due to additional changes to the LPPT program
- DRWM provides savings by reducing personnel required and eliminating tasks such as disconnecting the power range detectors
- DRWM reduces water processing since no change to boron concentration is needed
- DRWM using the Intermediate Range channel equals the accuracy of the DRWM using the Power Range channel and the rod swap techniques.
- RhoPRO™ can be used for any of the techniques for LPPT Westinghouse offers: DRWM with power range, DRWM with intermediate range, rod swap and boron dilution
- RhoPRO™ reduces control room space requirements and eliminates obsolescence issues for the Westinghouse ADRC
- RhoPRO™ automated data processing reduces likelihood of errors associated with manual data reduction
- RhoPRO™ connections to the plant I&C are simple and minimal

## Experience

Since 1996 when DRWM was first introduced, over 300 control rod worth tests during startups have been successfully performed worldwide using DRWM technology. Westinghouse has performed 12 demonstration applications, comparing the Intermediate Range-based results to the equivalent Power Range-based results, confirming the DRWM with intermediate range application and the RhoPRO™ reactivity computer equipment.



*Westinghouse RhoPRO™ Reactivity Computer System.*

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