Fuel Delivery

Alternate Rod Worth Verification (ARWV)

Post-refueling Startup Physics Test Optimization

Background

In response to an industry request to reduce the cost and effort associated with low power physics tests (LPPT) – particularly elimination of rod worth measurements – Westinghouse has developed its latest approach to optimize post-refueling startup physics testing.

Instead of performing explicit measurements on outage critical path, which necessitates several secondary tasks and administrative controls, the Westinghouse Alternate Rod Worth Verification (ARWV) program validates control rod worth based on statistical analysis and plant observations inherent to typical refueling outage activities.

The ARWV project scope includes a comprehensive review of the entire unit-specific startup test bases from core loading through full power operation. The final deliverable is a redefined and robust core design validation program that excludes direct rod worth measurements.

ARWV provides complete and flexible core design validation

Multiple "paths" for rod worth elimination are available to match various/changing customer needs

Significant potential issues remain identifiable

Adherence to reload safety evaluation method and industry standard guidance is maintained

The ARWV program provides various paths for eliminating rod worth measurement based on Westinghouse's extensive history of plant startup testing and advanced methods development. The approach for any given reload cycle startup can be tailored to plant preference, their use of/access to Westinghouse codes and methods, cycle-specific design changes, and the licensing basis.

Control rod worth measurements are replaced with statistical analysis of the predicted rod worth and evaluation of rod worth-related observations of the as-built core. All tasks can be completed pre-outage or within the typical refueling outage scope, which enables Operations to perform a normal reactor startup (i.e., similar to a mid-cycle startup).

The project scope also includes a detectability study of the overall ARWV-based startup test program from MODE 6 to MODE 1 (without performing rod worth tests) to confirm that the ARWV-based program's capability to identify safety-significant issues is greater than or equal to that of the plant's current startup test program.

The scope, performance sequence, and results evaluation of the various ARWV tests and activities are modelled after those of a traditional reload startup physics program, which ensures consistency with the overall intent of the ANSI/ANS-19.6.1 standard for reload startup physics testing.

ARWV delivers wide-ranging value

Minimizes critical path time between hot standby and power operation conditions

Eliminates all ancillary aspects of traditional LPPT

Enhances Reactivity Management and Human Performance

The ARWV program eliminates the critical path time previously associated with rod worth tests and supporting activities. If all associated criteria are met, the first post-reload power distribution measurement can be deferred to 50 percent rated thermal power (RTP).

The ARWV approach does not require a reactivity computer – i.e., special test equipment (STE) previously needed to perform rod worth measurements. Therefore, all tasks associated with STE transport to or across the plant site,

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staging, calibration, connection, operation, and maintenance, as well as all associated maintenance or instrumentation and control (I&C) support are eliminated[1].

The ARWV program intentionally avoids any complex or time-sensitive operator actions to minimize the risk of a reactivity or human performance event. In turn, this enables the plant to minimize infrequently performed test and evolution controls during reactor startup.

Deliverables

Standard project scope includes an initial evaluation of the plant's licensing basis to determine if the ARWV program can be implemented without prior United States (U.S.) Nuclear Regulatory Commission (NRC) approval.

Following review of the plant-specific startup test program and operating experience, a formal technical report is provided, which includes:

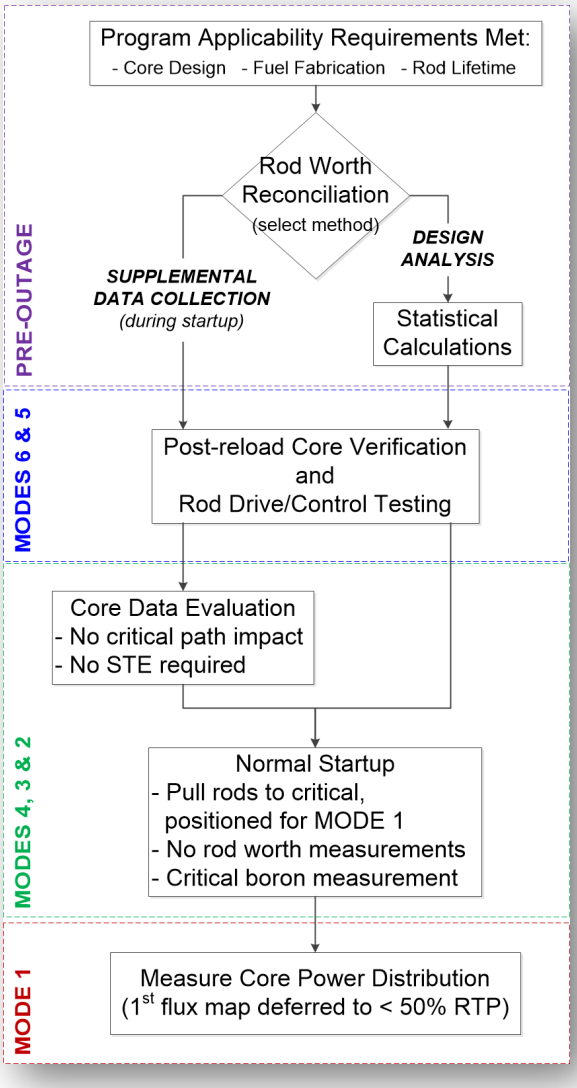
- The ARWV-based startup test program description and results evaluation criteria
- ARWV conditional applicability requirements
- ARWV implementation guidelines for use in generating plant procedures
- Change impact evaluation, including results of the detectability study
- Input to a plant-specific 10 CFR 50.59 screen/evaluation

Experience

The ARWV approach is founded on statistical analysis of Westinghouse's extensive global rod worth measurement experience. Since the mid 1990's, Westinghouse methods have been used to support over 400 successful plant startups (encompassing measurement of over 3,000 control rod banks) in six countries. This enables ARWV implementation on a vast array of cycle lengths, fuel enrichments, feed fuel fractions, and fuel and component types.

The ARWV approach draws on the precedence of the Startup Test Activity Reduction (STAR) methodology[2], which was developed for the Combustion Engineering (CE) Nuclear Steam Supply System (NSSS) fleet in the early 2000's. The CE STAR Program was approved by the NRC in 2005. To date, the STAR method has been successfully applied on eleven CE NSSS units at seven U.S. stations.

The ARWV program was developed in 2018-2019 in response to an industry request to optimize LPPT for U.S. Pressurized Water Reactors. In 2019-2020, Westinghouse delivered the ARWV program methodology and requirements to its first U.S. commercial customer.



Simplified flowchart for an optimized, ARWV-based reload startup test program

1 Use of a reactivity computer may be required for temperature coefficient surveillance purposes.

2 The ARWV program is not a direct extension of the generic NRC-licensed STAR program.

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