framatome

# Reactivity Measurement Analysis System (RMAS)

## RMAS delivers accurate, real-time reactivity measurements and efficient easy to learn physics test analysis tools to support reliable ZPPT validation.

## Challenge

Reactor startup physics testing is a challenging and vital part of any utility's outage. At a PWR, one of the last activities required prior to increasing power and placing the turbine online is to perform Zero-Power Physics Testing (ZPPT). This testing involves making precise measurements of various core parameters and comparing the measured results to predicted values. These predicted values define expected core performance and are derived using the same codes that license the reload core, making the ZPPT process an important part of verifying that the reload core is operating as designed.

## Solution

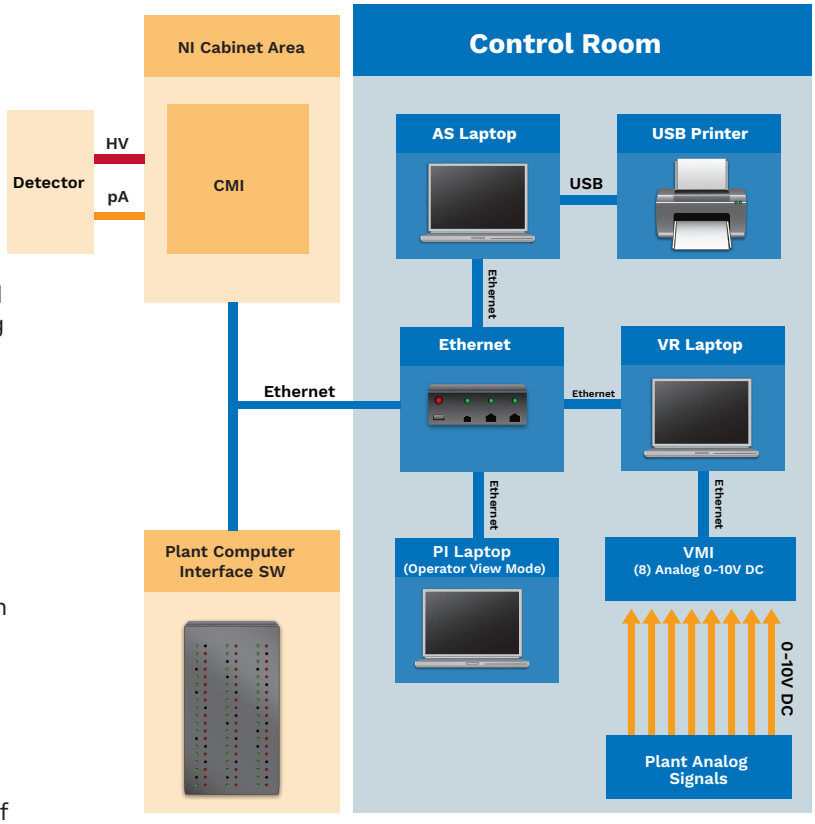
Framatome has incorporated more than 30 years of accumulating experience in the ZPPT phase of PWR startups in the continuous development and evolution of Framatome's Reactivity Measurement and Analysis System (RMAS). RMAS assists plants in the execution of their physics testing programs.

RMAS is a periodically used I&C system designed to interface with permanent plant equipment and perform real-time data acquisition, data processing, reactivity calculations, and data analysis. RMAS supports a variety of test methodologies for the various phases of ZPPT, validates new core design predictions, and automates the analysis of plant data.

## Current Usage:

**36 Reactor units**

12 Westinghouse
11 Combustion Engineering
6 Babcock and Wilcox
2 Framatome
1 U.S. Government Research Reactor
4 Framatome EPR™




*Generic RMAS Layout*

## Customer benefits

- Easy-to-use interface minimizing operator training time
- Standardized analysis methods aligned with industry PWR practices worldwide
- Flexible configuration adaptable to a wide range of PWR designs and plant requirements
- Immediate access to results and reports for faster decision-making
- Simplified data storage and reanalysis for improved traceability and long-term data management

## Proven Experience

RMAS has been used successfully in more than 400 PWR reactor startups to complete ZPPT in the United States, South Africa, Brazil, China, Finland and France. RMAS is also included as original equipment for the Framatome EPR reactors in Finland, France, and China.

## Achievable ZPPT Test Times with RMAS

| | |
|---|---|
| › Critical Boron Concentration<br>› Point of Adding Heat<br>› Reactimeter Checkout<br>› Temperature Coefficient | < 2 hours from criticality to end of four tests |
| › RodWorth (by Bank Dilution)<br>› RodWorth (by Rodswap) | < 3 hours |

## Continuous Improvement

Framatome has used state-of-the-art software tools to create a flexible and robust solution to aid in startup physics testing. Framatome continues to invest in and improve RMAS capabilities to provide continually improving benefits to our customers.

RMAS version 9 has the capability to simultaneously communicate directly with the plant data servers, digital instrumentation systems, and conventional analog voltage and current signals. Signals from multiple data sources are conditioned and aggregated into the analysis software for easy and efficient ZPPT completion.

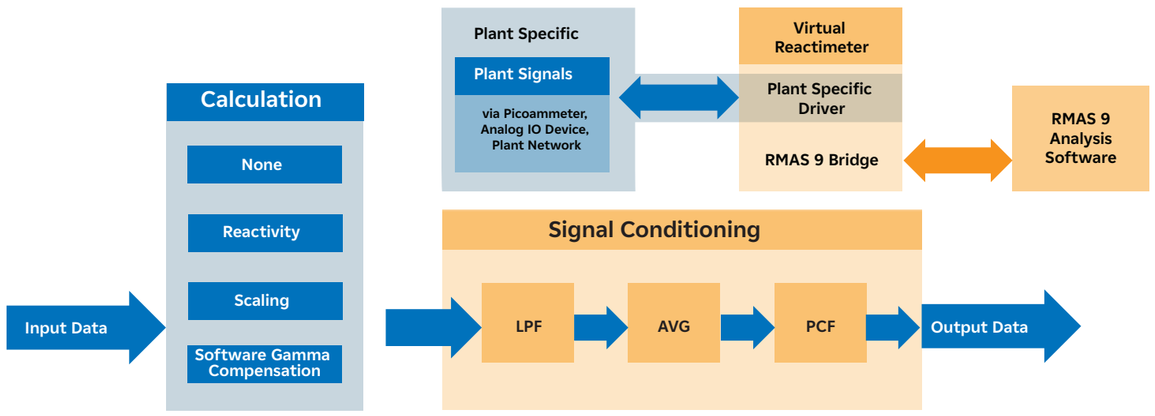
## Less Time — Less Risk

Utilities accomplish ZPPT with RMAS in less time, with less risk, and at significantly lower costs while employing conventional ZPPT methods. The use of RMAS and the associated services (training, procedure reviews, on-site engineering) has saved utilities many hours of critical path time every outage with real economic advantages.

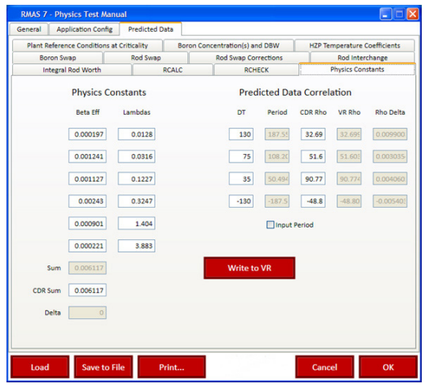
Framatome's RMAS is comprised of several major system components linked together. The core of the RMAS is the Reactimeter, which performs the reactivity calculation, provides the interface with the plant signals, and distributes information for analysis and operations.

RMAS includes a measurement instrument containing the laboratory quality devices to interface with reactor excore detectors and other plant signals.

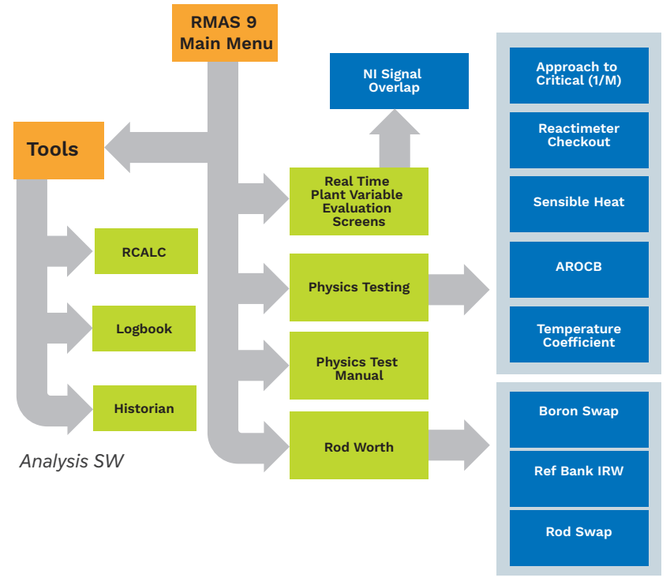
When used in conjunction with RMAS software, the complete system provides comprehensive ZPPT capability. The software includes features for signal conditioning that can provide accurate results from excore detector signals that contain significant noise, which is encountered regularly at many plants. Multiple excore detectors can be analyzed independently and simultaneously for greater certainty in the final result.




*Virtual Reactimeter Data Flow*




*Physics Constants Input, Core Design Report Correlation*

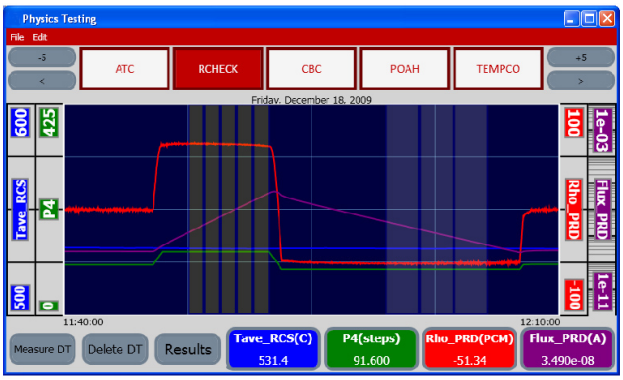



*Analysis SW*

## RMAS Analysis Software

The analysis software consists of a number of applications specifically designed to facilitate individual ZPPT requirements. Multi-tasking allows running several applications simultaneously. Important features of the analysis software applications are:

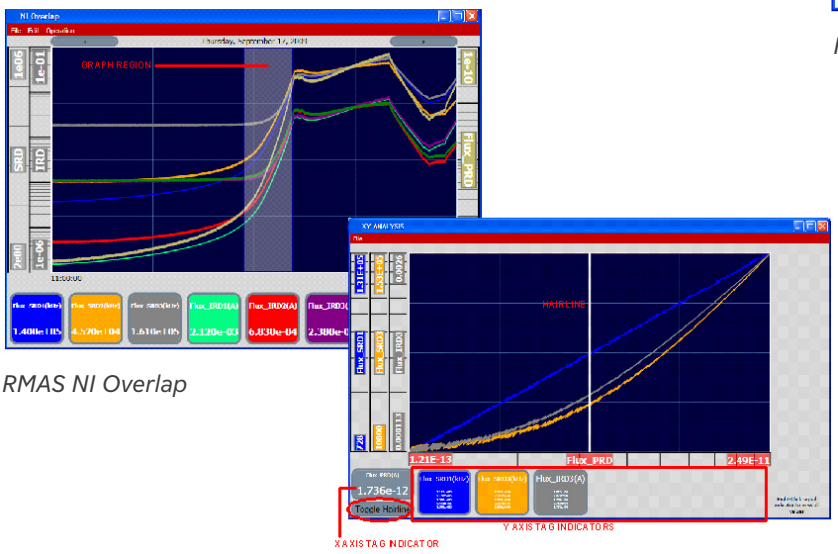
- Data input through real-time, simulation, file recall (open), file import (.csv, or comma-separated variable, data), and internal test modes
- Automated application codes for each ZPPT, including:
  - NI overlap (excore linearity check)
  - Approach to critical (1/M)
  - Point of adding heat
  - Reactimeter checkout
  - All-rods-out critical boron concentration
  - Temperature coefficient (state point and slope method)
  - Rod worth (by dilution and / or boration or rodSwap or rodInterchange)
  - Differential boron worth
  - Boron end point
  - Integral rod worth plots
- SQL Database, which continually logs all data and allows the utility to view, analyze, and download data in real time or past data
- Number and type of signals are completely configurable from a few to hundreds
- Simulated and Internal ramp testing to validate predictions and system performance
- Plant-specific configuration customization to generate on-line reports supporting plant-specific procedures
- Online help/instruction manual




*RMAS Reactimeter Checkout*

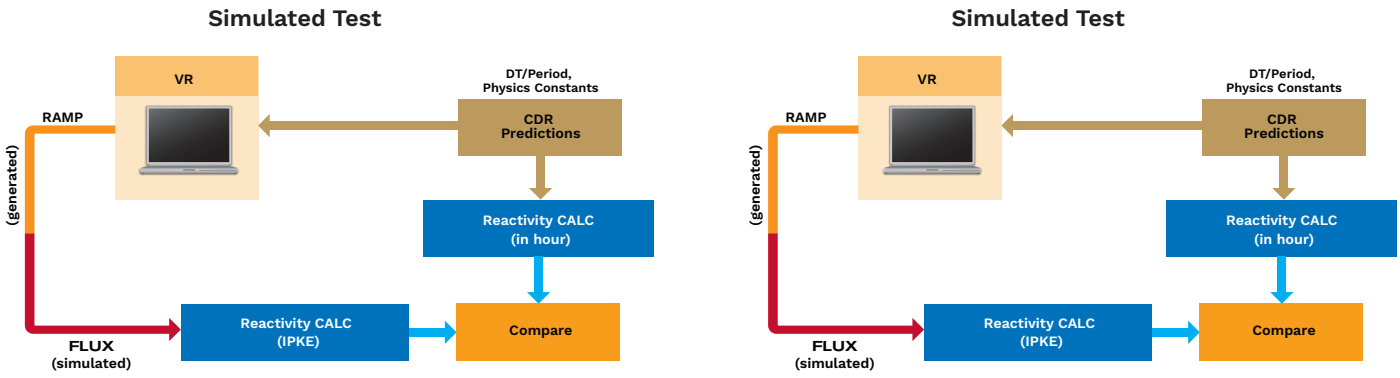



*RMAS RunTime: Statistics*




*RMAS NI Overlap*

## Diagnostic Features




**Contact: IC@framatome.com**
**www.framatome.com**

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