

Reactivity Measurement and Analysis System (RMAS)

A robust, next-generation solution for startup physics testing

Overview

AREVA has incorporated more than 25 years of accumulating experience in the Zero-Power Physics Testing (ZPPT) phase of PWR startups in the continuous development and evolution of AREVA'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:

- 37 Reactor units
- 12 Westinghouse
- 11 Combustion Engineering
- 6 Babcock and Wilcox
- 2 Framatome
- 2 U.S. Government Research Reactors
- 4 AREVA EPR™ Reactors (under construction)

Plant Reactor Engineering Support

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 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.

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 and has been included as original equipment for the AREVA EPRs being built in Finland, France, and China.

Achievable ZPPT Test Times with RMAS

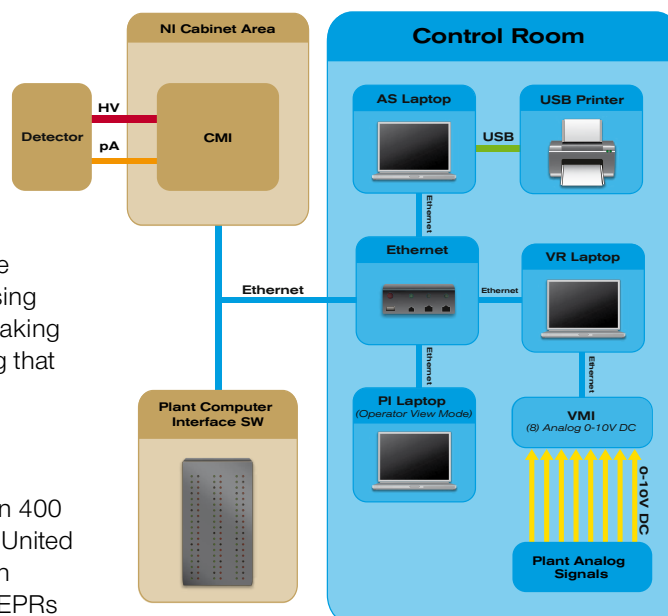
<ul style="list-style-type: none"> • Critical Boron Concentration • Point of Adding Heat • Reactimeter Checkout • Temperature Coefficient 	< 2 hours from criticality to end of four tests
<ul style="list-style-type: none"> • RodWorth (by Bank Dilution) • RodWorth (by Rodswap) 	< 3 hours

Continuous Improvement

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

RMAS Version 7 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.

Generic RMAS Layout



Less Time – Less Risk

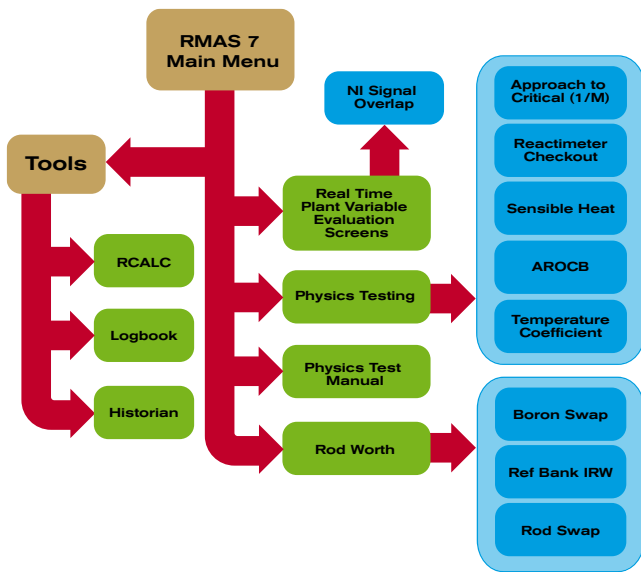
Utilities accomplish ZPPT with RMAS in less time, with less risk, and at significantly lower costs while employing conventional ZPPT methods. The use of RMAS and the associated services (training, procedure reviews, on-site engineering) has saved utilities many hours of critical path time every outage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

AREVA'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.

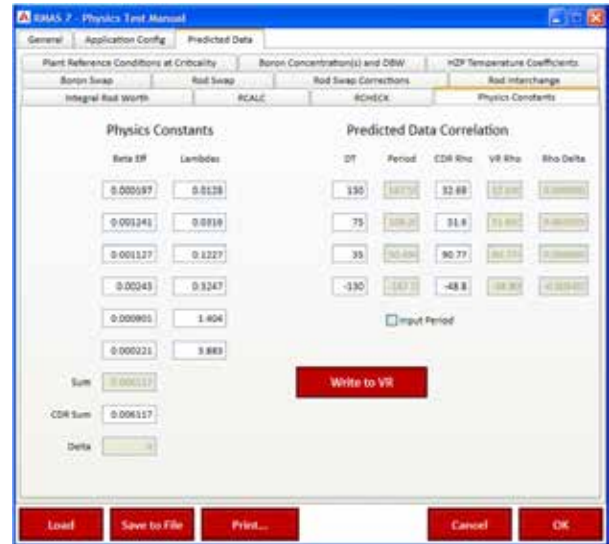
RMAS includes a measurement instrument containing the laboratory quality devices to interface with reactor excore detectors and other plant signals.

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.

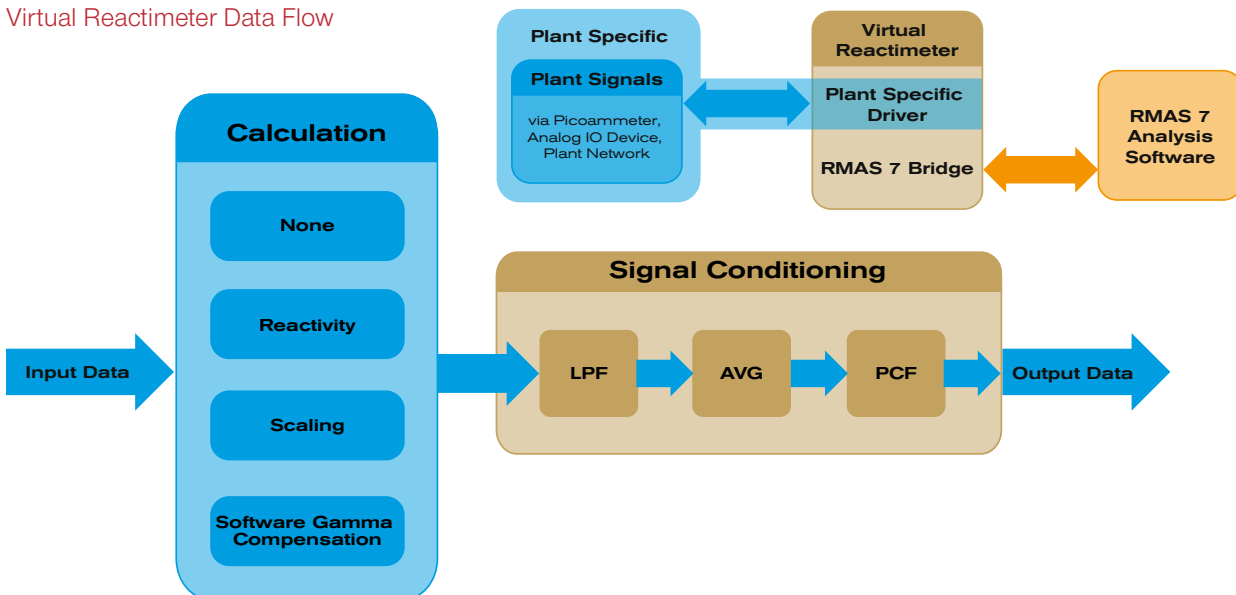
Analysis SW



Physics Constants Input; Core Design Report Correlation



Virtual Reactimeter Data Flow



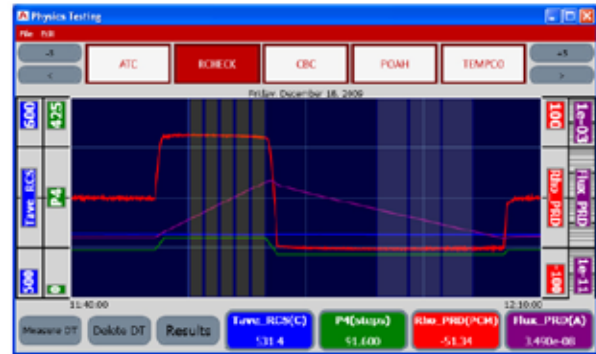
RMAS Analysis Software

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:

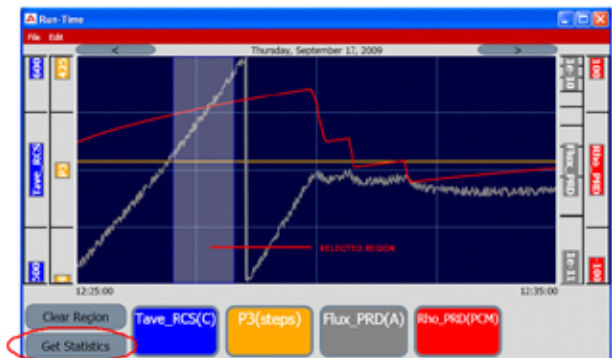
- Data input through real-time, simulation, file recall (open), file import (.csv, or comma-separated variable, data), and internal test modes
- Automated application codes for each ZPPT, including:
 - NI Overlap (excore linearity check)
 - Approach to critical (1/M)
 - Point of Adding Heat
 - Reactimeter 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



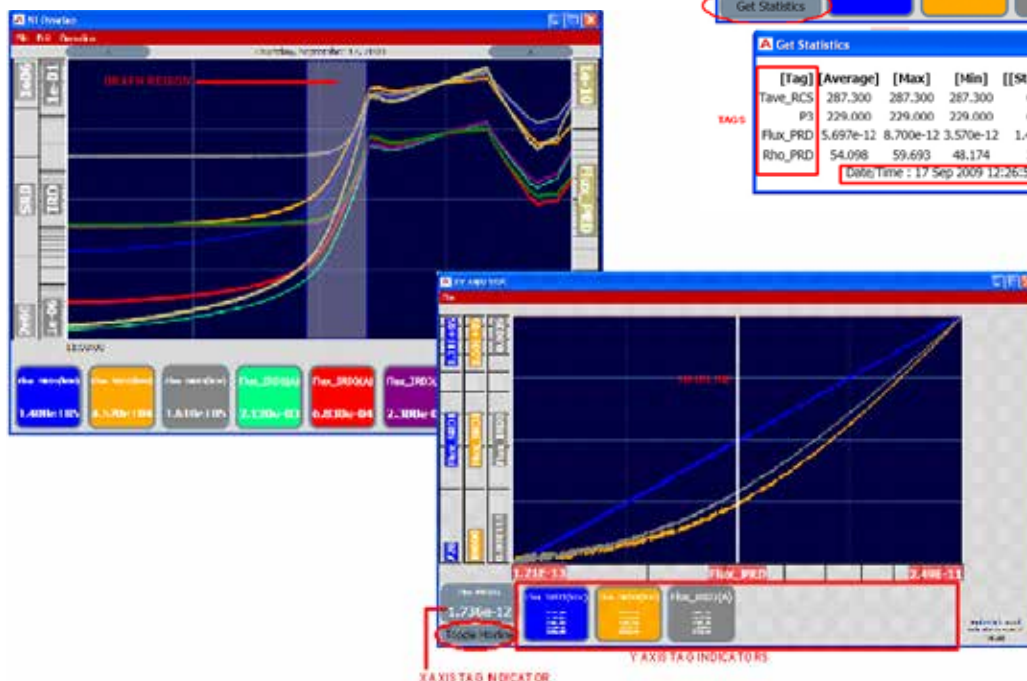
RMAS RunTime: Statistics



[Tag]	[Average]	[Max]	[Min]	[[Std. Dev.]]	[[Drift unit/hr]]	[[Slope unit/sec]]
Tave_RCS	287.300	287.300	287.300	0.000	0.000	0.000
P3	229.000	229.000	229.000	0.000	0.000	0.000
Flux_PRD	5.697e-12	8.700e-12	3.570e-12	1.437e-12	2.059e-10	6.127e-14
Rho_PRD	54.098	59.693	48.174	3.358	521.175	0.145

Note time : 17 Sep 2009 12:26:58 - 12:28:18

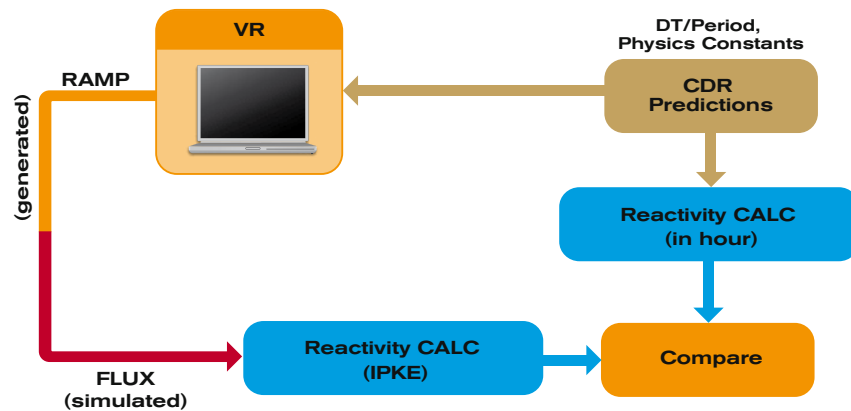
RMAS NI Overlap



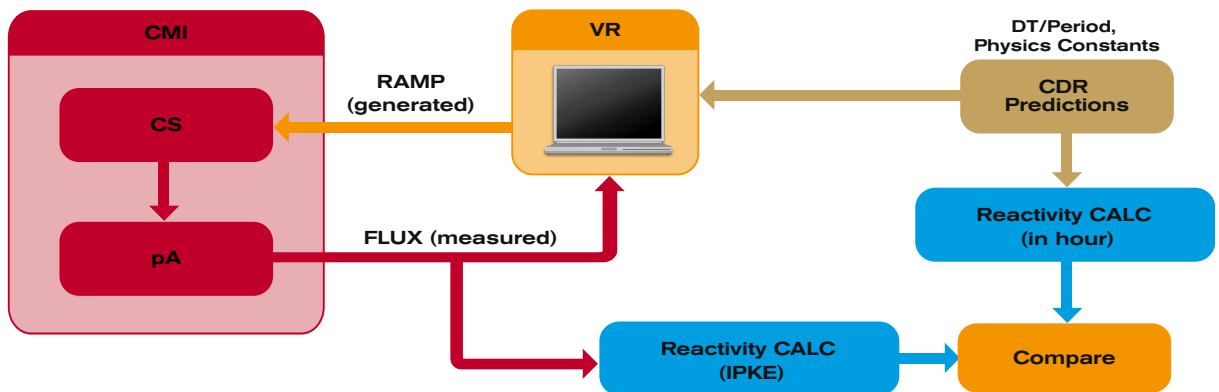
Features & Benefits:

- Reduces time-consuming analysis of reactivity traces
- Modular and network based
- Regression analysis based on user-selected regions of reactivity trace
- Easily verify proper choice of selected data and insertion point
- Results and report immediately available

Simulated Test



Internal Test



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