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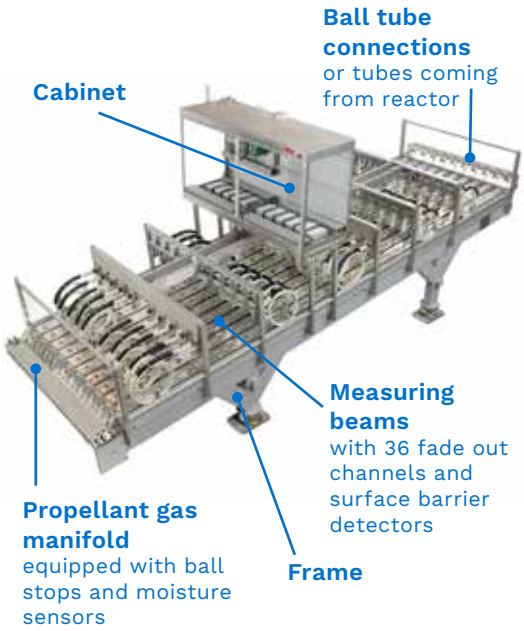
Aeroball Measurement System

Incore Neutron Flux Measurement

Accurate monitoring of neutron power density distribution with high level of local resolution provides greater margins for flexible operation.



Challenge

In pressurized water reactors (KONVOI, EPR) local power densities must be monitored. Power densities can be directly calculated from the neutron flux inside the reactor core. Neutron flux measurement provides instant information for verification of core conformity, nucleate boiling and detection of anomalies and serves as an input for core surveillance and protection systems. It also provides information for the calculation of fuel burn-up, required for effective fuel management.

Continuous and accurate incore neutron flux measurement is key to safe, reliable and effective plant operation.

Solution

Framatome offers a full range of nuclear instrumentation solutions, critical for safe and profitable plant operation throughout its entire lifecycle. We draw on over 60 years of expertise to support our customers' needs when it comes to neutron flux measurement solutions.

The Aeroball Measurement System (AMS) is an electro-mechanical, computer-controlled system that records a snapshot of incore neutron flux distribution.

The measurement principle is based on activation analysis. Steel balls containing an indicator nuclide are pneumatically transported into the reactor core. There, they are activated by the local neutron flux at the measurement position. After transportation to the measurement table, their activation is measured. Activation rates are directly proportional to incore neutron flux.

The short activation duration allows for reliable measurement even under transient core conditions, including load-follow operation. AMS continuously and accurately tracks core conditions, detects and diagnoses anomalies and most importantly, reduces radiation exposure for personnel. Framatome offers fully developed standard solutions including an obsolescence-resistant design to meet customer requirements.

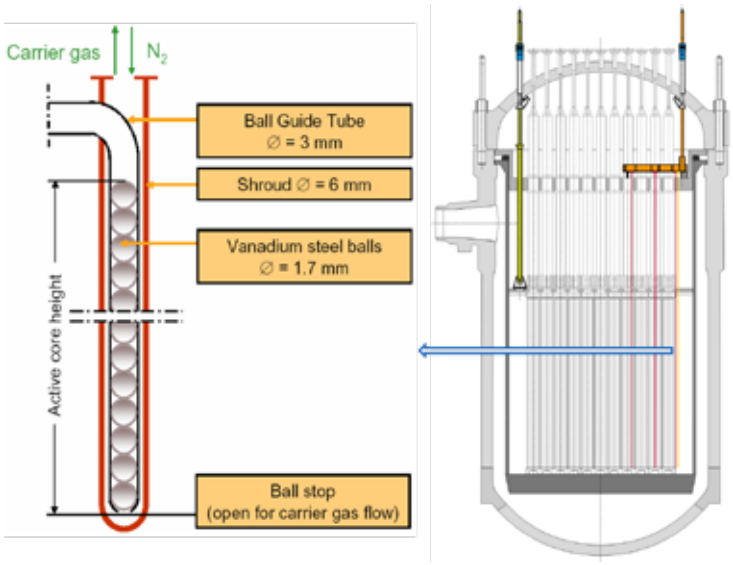
Customer benefits

Framatome's Aeroball Measurement System:

- creates optimized conditions for the load-following operation which increases the margin of the plant
- has no scheduled preventive maintenance during the cycle which reduces costs and personnel radiation exposure
- is largely automated which allows easy operation
- does not produce highly activated nuclear waste, thanks to the use of low activation and very fast decaying materials
- provides information during core transients (no core stabilization required), thanks to a very fast data acquisition
- improves plant safety by identifying core anomalies very early

Features

- No detector burn-up
- Reliable and stable signaling takes place under easily controllable conditions outside the core
- The measured activity distribution can be determined with an uncertainty below 1.4%
- Due to short activation time, measurement of the 3D power density distribution under transient core conditions is possible
- Rapid decay of indicator material ensures repeatable aeroball measurement with high accuracy every ten minutes
- 3D power density distribution can be measured with high spatial resolution (1,440 measuring points for EPR)



System Overview

PIPS detectors

Manual Control Station

Technical information

Architecture

- Exchangeable instrumentation (ECI) finger, comprising three or four aeroball tubes
- Forty aeroball tubes (for EPR) radially distributed over the reactor core
- Each tube contains a stack of aeroballs covering the complete active core zone
- Ball stacks grouped in four subsystems with ten ball stacks per subsystem
- Aeroballs contain vanadium as indicator material
- Aeroballs transported pneumatically with nitrogen

Measurement range

- Reliable measurement from 10% to 100% nuclear power
- Measurement compatible with MOX fuel

Measurement channel

- Passivated Implanted Planar Silicon (PIPS) detectors for radiation measurement
- DLEV-826H preamplifier
- SMC-SV5 serial micro 5 channel (amplifier, discrimination)
- IPG-50 test generator

Key Figures

Over **575** reactor lifetime years of aeroball measurement system

10 minutes measurement duration

40 instrumented core positions for EPR

References

- Netherlands (1), Switzerland (1), Spain (1), Brazil (1, 1*)
- EPR in China (2), Finland (1), France (1), United Kingdom (4)*

* Under construction

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