

Aeroball Measurement System

Incore Neutron Flux Measurement

Accurate monitoring of neutron power density distribution with high level of local resolution providing 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 for 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 an effective fuel management.

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

Solution

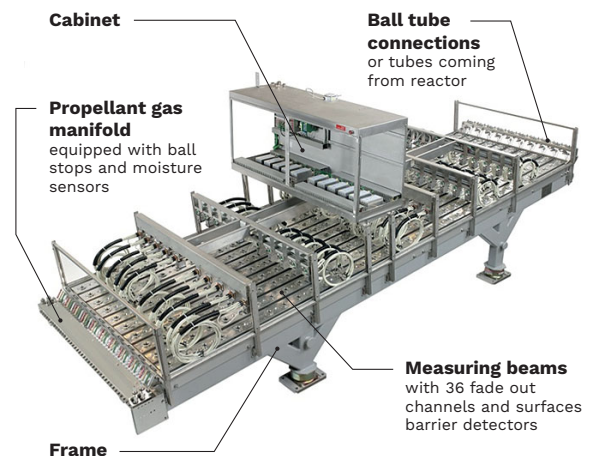
Framatome offers the full range of nuclear instrumentation solutions critical for the safe and profitable operation of the plant throughout its entire lifecycle. We draw on over 60 years of expertise to support our customers' needs when it comes to neutron flux measurement solutions.

The Aeroball Measurement System (AMS) is an electro-mechanical, computer-controlled system to record a snapshot of the neutron flux distribution in the core.

The measurement principle is based on an activation analysis with steel balls containing an indicator nuclide. The balls are pneumatically transported into the reactor core where they are activated by the local neutron flux at the measurement position. Afterwards, they are transported to the measurement table where their activation is measured. The activation rates are directly proportional to the neutron flux in the core.

The short activation duration allows a 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 the personnel. Framatome solutions are customizable to meet all customer requirements and can be effectively integrated into existing I&C systems.



AMS measurement table

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 maintenance costs and personnel radiation exposure
- is largely automated which allows an 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

Your performance
is **our** everyday **commitment**

Technical information

Architecture

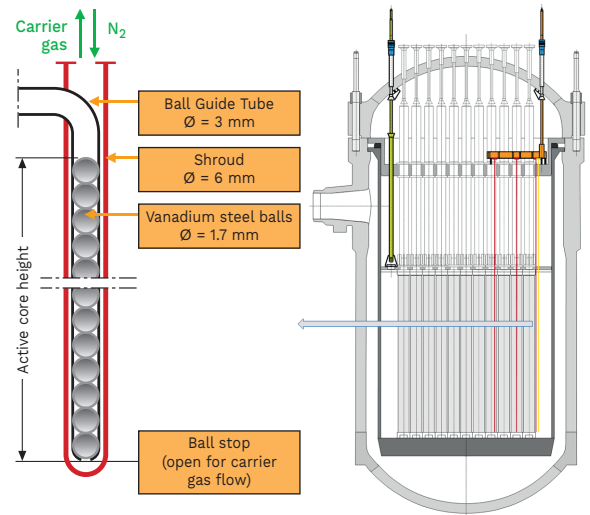
- Exchangeable instrumentation (ECI) finger, comprising 3 or 4 aeroball tubes
- 40 aeroball tubes (for EPR) radially distributed over the reactor core
- Each tube contains a stack of aeroballs covering the complete active core zone
- Ball stacks grouped in 4 subsystems with 10 ball stacks per subsystem
- Aeroballs contain vanadium as indicator material
- Aeroballs are transported pneumatically with nitrogen

Measurement range

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

Measurement channel

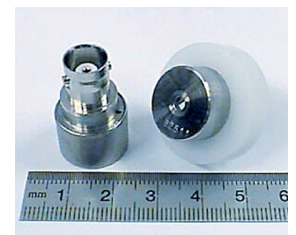
- Passivated Implanted Planar Silicon (PIPS) detectors for radiation measurement
- DLEV preamplifier
- SMC serial micro channel (amplifier, discrimination)
- IPG test generator



System Overview



Manual Control Station



PIPS detectors

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% (1 sigma value)
- Due to short activation time, measurement of the 3D power density distribution under transient core conditions is possible
- Rapid decay of indicator material ensures the possibility to repeat an aeroball measurement with high accuracy every 10 minutes
- 3D power density distribution can be measured with high spatial resolution (1,440 measuring points for EPR)

Key figures

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

10 minutes measurement duration

40 instrumented core positions for EPR

References

- PWRs in Germany (6), Netherlands (1), Switzerland (1), Spain (1), Brazil (1)
- EPR in China (2), Finland (1)*, France (1)*, United Kingdom (2)*

* Under construction

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