

Continuous Measurement of Prompt Incore Neutron Flux in PWRs

Essential to Protect and Control a PWR

System designed to continuously measure the thermal neutron flux inside the reactor pressure vessel (RPV) using self-powered neutron detectors (SPNDs) using cobalt as a neutron-sensitive material

Challenge

The thermal neutron flux of a reactor is a measure for the instantaneous nuclear power. The continuous measurement of the neutron flux directly inside the reactor core provides information on local power fluctuations, nucleate boiling as well as the radial and axial power distribution, including imbalances. Prompt-responding, safe and reliable incore neutron flux instrumentation is thus essential for reactor protection and control.

Solution

We at Framatome design incore neutron flux instrumentation equipment and systems, which comply with customer-specific reactor types such as pressurized water reactors (PWRs).

The prompt-responding neutron-sensitive cobalt allows the incore neutron flux instrumentation system to monitor quick changes in local conditions inside the reactor core. The resulting signal can be used for reactor protection as well as surveillance. The system allows a filtering of neutron flux noise reducing the actuation of countermeasures based on fluctuations of the signal.

Based on more than 40 years of operational experience, our system is qualified to operate under normal reactor operating conditions and in contact with the primary coolant. The equipment outside the RPV is also designed to withstand accident conditions.

Our in-core neutron flux instrumentation is designed for simple operation, maintenance and minimum radioactive waste, while enhancing the operational margins by allowing fast nuclear power transients, and improving reactor safety.

We provide all services for the complete system, including equipment and system qualification according to international standards, hardware, training of personnel, comprehensive testing and maintenance.

Furthermore, we offer support to integrate the system into existing instrumentation and control (I&C).



Framatome Co-SPND

Customer benefits

- Prompt-responding continuous neutron flux measurement allows higher operational margins
- Qualified to be used for reactor protection
- Optimized for load-follow operation
- Allows quick reactor startup after outages
- Simple operation and easy to maintain
- Supply of complete system, including integration into existing I&C or equipment

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

Technical information

Qualified components and system, partially adjustable to plant-specific needs:

- Exchangeable instrumentation (ECI) finger, comprising six Co-SPNDs for prompt neutron flux measurement and three K-type thermocouples for measurement of fuel assembly exit temperature
- Fuel assembly exit temperature measurement: severe accident-proof measurement, designed also for post-accident mitigation
- Cables inside RPV: mineral-insulated Inconel cable
- Cables outside RPV: flexible accident-proof system cables for SPNDs and thermocouples
- Connectors (accident-proof)
- Pressure-tight penetration through vessel head
- Analog signal conditioning and customizable digital signal processing, including maintenance equipment
- Customized maintenance program and optional on-site support



Signal conditioning module

Key figures

350 instrumentation fingers installed

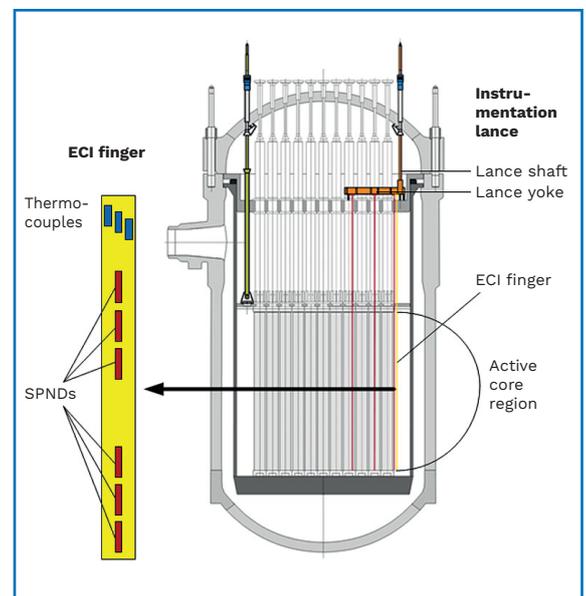
40 years operational experience with the system in numerous nuclear power plants

10 years qualified lifetime of a detector assembly

0 second delay of the detector response following changes in thermal neutron flux

36 hours needed for a plant with a Co-SPND system to reach 100% nuclear power

20 annual worldwide power production records of plants with a Co-SPND system



System overview (sensor part)

References

- PWRs in Germany (6), Netherlands (1), Switzerland (1), Spain (1), Brazil (1)
- EPR reactors in China (2), Finland (1)*, France (1)*, Great Britain (2)*

*under construction

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