

Incore Detectors with Continuous Neutron Flux Measurement

Essential to ensuring the protection and control of pressurized water reactors (PWRs), Framatome's incore detectors utilize self-powered neutron detectors incorporating neutron-sensitive cobalt (Co-SPNDs) to constantly compute, without interruption, thermal neutron flux inside the reactor pressure vessel, enabling real-time core power monitoring.

Challenge

Power generating utilities with PWRs need immediate and direct monitoring of local core power conditions, including dynamic processes such as xenon oscillations or power fluctuations to facilitate efficient reactor operation and fast transients for load-follow operation and homogeneous fuel burnup.

Solution

Framatome's continuous, prompt-response, Co-SPND-based neutron flux monitoring system enables highly efficient plant operation, close to the physical limits, while supporting homogeneous fuel burnup. It's engineered to be easy to operate and maintain, while also minimizing the production of radioactive waste. Additionally, it enhances reactor safety and operational margins by enabling rapid nuclear power transients.

The Co-SPNDs, embedded in instrumentation fingers and lances, are integrated in a complete flux measurement solution designed by Framatome. This solution is functionally and mechanically adaptable to various types of PWR and small modular reactors.

With a design based on more than 50 years of operational experience, Framatome's continuous incore neutron flux instrumentation system is qualified to operate during normal reactor conditions while in contact with the primary coolant. The equipment is also designed to withstand accidental conditions, such as loss-of-coolant accidents.

A large range of services can be provided within the complete system, including design, manufacturing, integration and testing, installation and maintenance, and qualification according to international standards. For modernization projects, Framatome is studying the possibility of integrating this solution into existing instrumentation and control and core monitoring systems.



Framatome Co-SPND with connector

Customer benefits

- Higher operational margins due to prompt-response continuous neutron flux measurement
- Optimized load-follow operation and fast reactor power changes
- 10+ year lifetime allows for limited equipment maintenance
- Customizable, flexible, modular system architecture: full or partial scope solutions available
- Safety-qualified for use in reactor protection or surveillance

Technical information

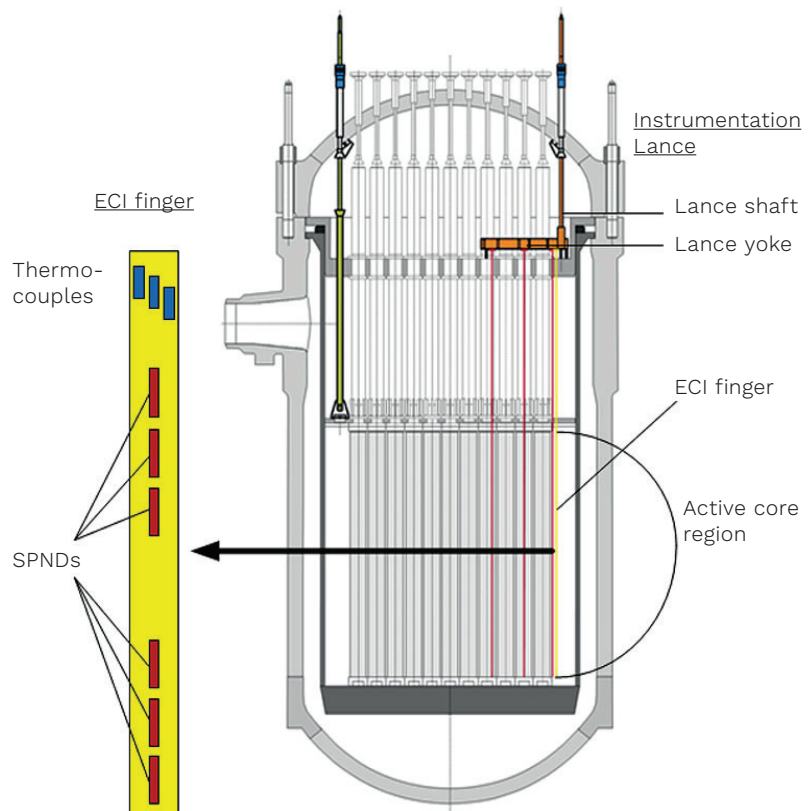
Qualified components and system, adjustable to plant specific needs:

- ExChangeable instrumentation (ECI) finger comprising of six Co-SPNDs and three type K thermocouples allows for prompt neutron flux and fuel assembly exit temperature measurements
- Neutron-sensitive cobalt generates instantaneous response to neutron flux, allowing the system to monitor quick changes of local conditions inside reactor core



Signal conditioning module

- Severe accident-proof temperature measurement of fuel assembly exit also designed for post-accident mitigation
- Accident-proof system cables for SPNDs
- Thermocouples with multi-pin connectors
- Analog signal conditioning and customizable digital signal processing, including test equipment



System architecture inside reactor pressure vessel

Features

- System developed and qualified:
 - For CAT - A safety functions according to IEC 60780
 - According to national regulations and international standards RCC-E / KTA
- Customized maintenance program and optional on-site support

Key Figures

400 instrumentation fingers installed worldwide

50 years operational experience for the system in nuclear power plants

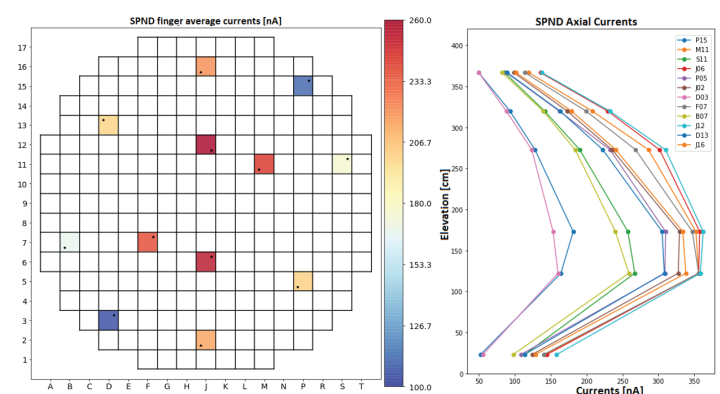
20 annual energy production records of plants with a Co-SPND system

10 years qualified detector assembly lifetime (exchangeable)

0 detector response delay following nuclear power changes

References

- Active plants in Switzerland (1), Spain (1), Brazil (1), Argentina (1), China (2), Finland (1), France (1)
- Plants under construction in Brazil (1), France (6), Great Britain (4)



Radial and axial SPND raw signals in EPR (operational data)

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