In-Core Flux Detector

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Classification

- **Self-powered neutron detector**: small, inexpensive, and rugged enough to withstand the in-core environment
- **Wide range fission chamber**: using U-235 coating, operate in higher gamma fields than ion chamber, especial useful as pulse chamber (traveling flux detector TFD)
- **Activation Foils and Flux wires**: measure reactor neutron flux profile, movable

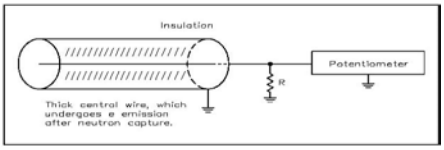
Self-powered neutron detectors

- Need no power supply
- Simple and robust structure
- Small mechanical size
- Good stability under temp and pressure condition
- Generate a reproducible linear signal
- Low burn-up (dependent on emitter material)

- Limited operating range due to low neutron sensitivity
- Compensation for background noise required (for some)
- Delayed signal response (for some emitters)

Theory

- The central wire of a self-powered neutron detector is made from a material that absorbs a neutron and undergoes radioactive decay by emitting an electron (Beta decay)



General consideration

- Monitor not only the mean valve of the in-core flux but also its spatial distribution
- Measure of local flux are necessary for safety reasons
- Provide information of a more general nature about component performance
- In some reactors, neutron flux outside the primary envelop can not used for start-up
- Special in-core instrumentation may be needed to facilitate periodic recal of the neutron flux inst
- Exposed to high neutron and gamma radiation, suitable material must be chosen.
- Adequate system availability must be provided due to the inaccessibility of the detectors

Emitter material characteristics

Material	Thermal n σ (10^{-24} cm^2)	Delayed n	Prompt n	Prompt γ	Appication
Co^{59}	37	o	x	o	LWR flux mapping LWR control Local Core Protection
Pt^{195}	24	o	x	x	LWR control HWR control
Rh^{103}	145	x	-	-	LWR Flux mapping
V^{51}	4.9	x	x	o	HWR Flux mapping LWR Flux mapping
HfO2	115	o	x	o	RBMK flux mapping RBMK local control RBMK local protection
Ag	64.8	x	-	-	RBMK Flux mapping

Vanadium emitter

- V51 has a n-β interaction with a thermal neutron cross-section of 4.9 barns without resonances in the energy range of thermal/epithermal neutrons
- The burn-up rate is 0.012%/month in a thermal neutron flux of 10E13 n/cm2/second
- 99% of the signal has a half-life of 3.76 minutes, 1% of the signal is prompt
- There is a parallel β emission of 2.6 MeV
- Relative low sensitive, low burn-up rate, minimal perturbation of local power density, but has a very long delay signal

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Platinum emitter characteristics

- 24 barn thermal neutron cross-section and a parallel gamma-photon reaction
- The signal is prompt and has both neutron and gamma components
- 93% of prompt fraction due to gamma flux and 7% due to neutron flux response in a typical light water reactor core
- Relative low sensitivity, low burn-up rate and a prompt signal

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Calibration

- Absolute calibration: the absolute neutron sensitivity may be determined by wire activation analysis. Sensitivity is readily calculated.
- Comparison calibration: compare to standard one
- In-core calibration:
  - Characterized by no or low burn-up factors (vanadium)
  - Single or multiple movable in-core fission chambers
  - Columns of steel balls with vanadium content moved by air or other gas which are irradiated in-core and later have their induced activity measured out-of-core.