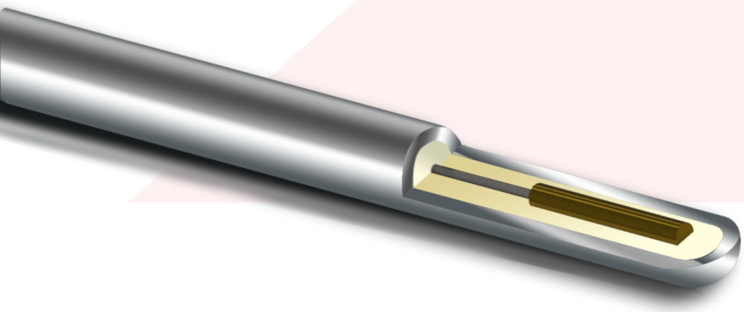
SELF POWERED NEUTRON DETECTOR (SPND)

TEMPSENS



Self Powered Neutron Detector (SPND)

Self Powered Neutron Detectors (SPNDs) are being widely used to monitor in-core neutron flux for control, safety, and mapping applications because of their small size, ruggedness and simplicity. These detectors use the basic radioactive decay process of its neutron activation material to produce an output signal. As the name implies, no external source of ionizing or collecting voltage is required to produce the signal current. Depending on the response time, these detectors are broadly classified as prompt and delayed response detectors. Prompt response detectors as Cobalt and Inconel are used in reactor protection and regulation applications, whereas the delayed response detectors like Vanadium and Rhodium are being widely used for Flux Mapping System.

Self-Powered Neutron Detectors (SPNDs) have been used effectively as in-core flux monitors for over twenty-five years in nuclear power reactors world-wide. The basic properties of these radiation sensors include nuclear, electrical and mechanical characteristics. The proper choice of the self-powered detector emitter to provide the proper response time and radiation sensitivity desired for use in an effective in-core radiation monitoring system.

General Characteristics of SPNDs

In Self-Powered Neutron Detectors (SPNDs), the interactions of neutrons and atomic nuclei are used to produce a current which is proportional to the neutron fluence rate (flux).

Compared to other in-core detectors, they feature some advantages

- Need no power supply.
- Simple and robust structure.
- Relatively small mechanical “size” desired for in-core installation.
- Good stability under temperature and pressure conditions.
- Generate a reproducible linear signal.
- Low burn-up (dependent on emitter material).

In addition, there are also some disadvantages

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

Mechanical Structure and Characteristics of SPNDs

- The typical SPND is a coaxial cable consisting of an inner electrode (the emitter), surrounded by insulation and an outer electrode (the collector). Preferably, the lead cable and detector sections may be integral or non integral.
- Integral SPNDs, the signal wire of the lead cable mates directly to the emitter; the insulation of both sections are identical and the collector of the detector section is also the outer sheath of the lead cable section. Detectors constructed in this manner are termed Integral SPNDs. (See Figure 1)
- Non integral or Modular SPNDs, SPND assemblies may also be made from separate detector and lead cable sections and are termed non integral or Modular SPNDs. (See Figure 2)

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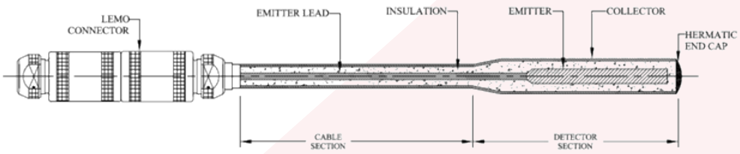
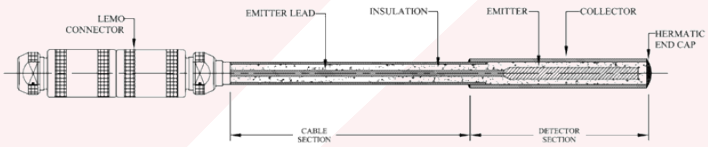
Figure 1



MECHANICAL STRUCTURE OF TYPICAL INTEGRAL SPND

Figure 2



MECHANICAL STRUCTURE OF TYPICAL NON INTEGRAL / MODULAR SPND

Specification of Typical SPNDs

S. No.	Description	Specification
1	Mechanical structure type	Integral , No integral
2	Emitter Material	Inconel 600, Rhodium, Vanadium, Cadmium, Platinum, Silver, Cobalt etc.
3	Insulation Material (for Detector section and lead cable section)	Magnesium Oxide (MgO), Alumina Oxide (Al2O3)
4	Collector Material	Inconel 600, Stainless Steel
5	Sheath Material of lead Cable section	Inconel 600, Stainless Steel
6	Lead material of Lead cable section	Inconel 600
7	No of lead	One or two
8	Emitter Diameter	Can be made upon request
9	Emitter length	
10	Collector Diameter	
11	Collector Length	
12	Cable section Diameter	
13	Cable Section length	
14	Cable Lead Diameter	
15	Collector and cable Sheath Thickness	
16	Connector Type	LEMO Connector, BNC Connector, etc.
17	Insulation resistance at 20°C	$\geq 10^{12}\ \Omega$
18	Insulation resistance at 300°C	Insulation resistance at 300°C
19	Production Quality testing	Dimension Test
		Continuity Test
		Insulation Compaction Density Test
		Insulation Resistance Measurement Test at Room temperature and elevated Temperature
		Capacitance Measurement test
		Water Immersion Test for Sheath integrity
		Hydrostatic Pressure Test
		Radiography Examination Test
		Helium Leak rate Test
		Steam test (Autoclave test)
		Bend Test
		Weld joint Quality Test (liquid Penetration Test)

Heat Flux Sensor

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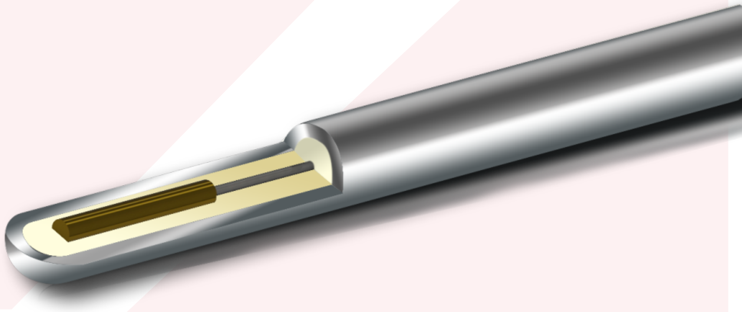
Classification of SPNDs:

SPNDs are classified as per different type of emitter material.

Some kind of SPNDs as follow:

1) Inconel SPNDs
2) Vanadium SPNDs
3) Rhodium SPNDs
4) Cadmium SPNDs
5) Platinum SPNDs
6) Cobalt SPNDs
7) Silver SPNDs



Nuclear Characteristics

For power reactor applications, typical emitter materials used in SPNDs include Inconel, Rhodium, Vanadium, Cobalt, Hafnia, Platinum and Silver. These materials should be used because they possess relatively high melting temperatures, relatively high cross sections to thermal neutrons and are compatible with the SPND manufacturing process.

Other emitters such as Cadmium, Gadolinium and Erbium may be used in SPNDs, but are not practical for power reactor applications

Some of the characteristics of SPND emitter are as follow for reference

Emitter Materials	Thermal Neutron Cross Sections	Response time	Burn-up Rate (%/Month at 1013nv)
Co59	$37x10^{-24}$ cm^2	Prompt	0.09
Pt195	$24x10^{-24}$ cm^2	Prompt	0.03
Rh103	$145x10^{-24}$ cm^2	Delayed	0.39
V51	$4.9x10^{-24}$ cm^2	Delayed	0.01
Ag	$64.8x10^{-24}$ cm^2	Delayed	0.16
Hf02	$115x10\text{-}^{24}$ cm^2	Prompt	0.30
Inconel 600	-	Prompt	-

Note: The above Nuclear Characteristics value taken from other website. These specifications are not in our Scope.

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