Reuter-Stokes
a Baker Hughes business

Gamma Thermometers

Gamma sensitive detector for power monitoring in new nuclear plant designs

Precise, durable, efficient reactor power measurement

Gamma thermometers (GT) are proven sensors that use differential thermocouples to measure local gamma flux up to reactor full power. Although these gamma thermometers have generally been used in local power range monitors (LPRMs), they can be a fundamental component for new plants designs.

Reuter-Stokes has several decades of experience manufacturing gamma thermometers which have been used for calibrating LPRM fission chamber detectors in boiling water reactor (BWR) plant designs. Because gamma thermometers require no drive mechanism and remain in place during normal reactor operation, they provide a durable, efficient alternative to gamma traversing incore probe (TIP) and neutron TIP detectors for LPRM calibration. Unlike neutron TIP detectors, gamma thermometers can provide independent LPRM power readings throughout reactor power operation without sensitivity depletion.

Reuter-Stokes gamma thermometers have been tested in four operating reactors in the U.S., Japan, and Mexico, including multiyear testing for up to 10 years.

Benefits

- Fixed in-core assembly
- Compact size, no drive equipment required
- Continuous measurement for in-situ power monitoring and fission chamber calibration
- No fissile material
- Low cobalt construction to minimize neutron activation lowering radiation exposure and reducing disposal costs
- More accurate representation of reactor power

Product configuration and operation

Gamma thermometers are stainless steel rods with short sections that are thermally insulated from the reactor coolant by chambers of Argon gas. Interactions between the gamma flux and stainless steel sensor generate heat in the gamma thermometer. A thermally isolated thermocouple junction and a reactor water-cooled thermocouple junction create a measurable temperature differential that is proportional to the gamma flux. At steady-state reactor power condition the gamma flux is then used to calibrate fission chamber sensitivity and measure reactor power.

Each gamma thermometer includes an integrated heater wire providing GT calibration against a known heat source independent of the gamma flux. Gamma thermometer calibration provides a repeatable response curve of thermocouple output from a known given heat input which is used to correlate sensor response with gamma flux.

Applications

Gamma thermometers are typically integrated in LPRMs and installed as a single GT LPRM device for nuclear power instrumentation (non-safety) applications.

The U.S. Nuclear Regulatory Commission has outlined a gamma thermometer methodology for calibrating in-core instrumentation in reactor monitoring. Some ASME Code assemblies have included Reuter-Stokes gamma thermometers.

As the nuclear industry is growing, gamma thermometers can be an integral piece of your control philosophy and risk mitigation strategy.

Customizable solutions

Reuter-Stokes can customize gamma thermometers for a variety of lengths with various chamber lengths and positions, up to a maximum of 9 chamber locations within a GT detector assembly. We can incorporate the GT into a combined assembly with other types of detectors.

Specifications

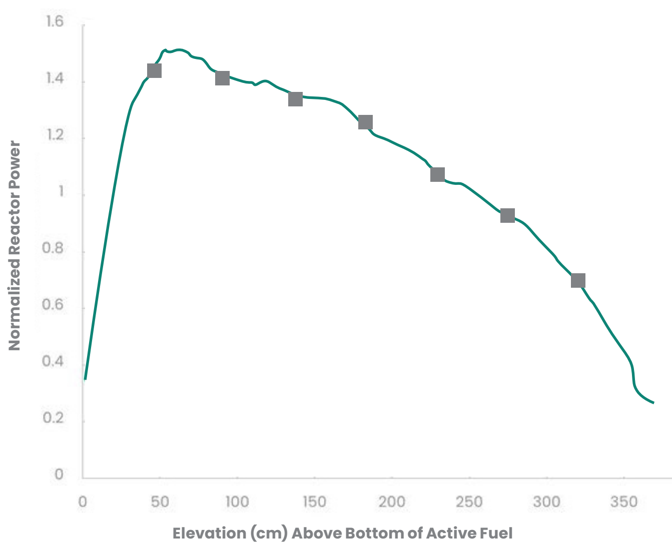
Mechanical

- Maximum diameter: 0.313 in
- Maximum overall length: customizable
- Connector: LEMO
- Heater cable power supply: 3 amp 200V

Materials

- Outer and middle shell: low cobalt SS316L
- Inner shell: SS316L
- Active portion of heater cable: NiCr
- Connector: SS304L
- Thermocouple Type K
- Thermocouple and heater cable insulation: Al_2O_3

Gamma thermometer accuracy validation vs gamma TIP



■ Gamma TIP power normalized

— Gamma thermometer power normalized

Table 1:

Gamma thermometer service environments	
Environment	
Coolant temperature	300°C
Pressure	1500 psia
Coolant water flow rate (min)	5 ft/sec
Seismic	
Operational Basis Earthquake (OBE)	2.24g vertical
Safe Shutdown Earthquake (SSE)	3.24g vertical
Radiation	
Gamma flux (max)	2.2×10^9 R/hr
Thermal neutron flux (max perturbed)	2.8×10^{14} nv
Lifetime	
Exposure weighted average thermal neutron flux (in ABWR at 60 kW/l, perturbed) for 10 years	8.9×10^{13} nv
Exposure weighted average fast (1 MeV) neutron flux (in ABWR at 60 kW/l, perturbed) for 10 years	7.5×10^{13} nv
Readings	
Response rate (hot junction time constant)	~20-30 sec
Output reading units	mV

Baker Hughes