

## Fiber Optic Isotope Sensor Testing



### Overview

Testing of fiber optic based sensors for advanced reactors in the The first experiment was conducted on February 8-9, 2021, to test the insertion and remov.

### Key Takeaways

Fiber optic isotope sensors, often based on Fiber Bragg Gratings (FBGs), are tested for temperature, pressure, and radiation resilience to ensure accurate monitoring in isotope production and nuclear medicine applications.Principles of Fiber Optic Isotope Sensors

Fiber optic sensors, particularly FBGs, operate by reflecting a specific wavelength of light determined by the refractive index and periodic structure of the fiber core. Changes in temperature, strain, or pressure cause shifts in the Bragg wavelength, which can be precisely measured using optical gauge amplifiers (OGAs) to detect small variations in the environment . These sensors are ideal for radiation environments because the measurement technique is largely insensitive to light attenuation caused by radiation-induced darkening of the fiber .

### Testing Methodologies

Testing fiber optic isotope sensors involves several key steps:

- Calibration and Baseline Measurement: The FBGs are first characterized under controlled conditions to establish baseline Bragg wavelengths and sensitivity to temperature and strain .



- **Radiation Exposure Testing:** Sensors are exposed to proton, neutron, or gamma radiation to simulate operational conditions in isotope production. The reflected wavelength is monitored to assess radiation-induced shifts or attenuation .
- **Temperature and Pressure Response:** Controlled variations in temperature and pressure are applied to verify the sensor's response and cross-sensitivity, ensuring accurate readings in complex environments .
- **Spectral Analysis:** The OGA scans the reflected spectrum to detect any optical distortion or wavelength drift, with typical measurement uncertainty around  $\pm 0.005$  nm .
- **System Integration Testing:** Sensors are tested within the full fiber optic system, including connectors, splices, and adapters, to evaluate end-to-end performance and insertion loss, similar to standard fiber optic system testing protocols .

#### Performance Considerations

- **Radiation Tolerance:** FBGs in inorganic fibers can withstand high doses (e.g., up to 472 Gy) with minimal impact on wavelength measurement .
- **Temperature Cross-Sensitivity:** Accurate strain or pressure measurements require compensation for temperature-induced wavelength shifts .
- **Signal Integrity:** The OGA method ensures that wavelength measurements remain reliable even if reflected power decreases due to fiber darkening .
- **Multiplexing Capability:** Multiple FBGs can be deployed along a single fiber for distributed sensing, which is useful in isotope production targets or nuclear medicine setups .

#### Applications

Fiber optic isotope sensors are used in:

- Isotope production targets for nuclear medicine to monitor temperature and pressure in real-time.
- Radiation therapy dosimetry, where small, flexible sensors provide localized feedback within catheters or applicators .
- High-radiation industrial environments, where conventional electronic sensors may fail. By combining precise optical measurement, radiation resilience, and system-level testing, fiber optic isotope sensors provide reliable monitoring for critical nuclear and medical applications.

## Article Content

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A fiber optic cable can act as the communication path between a test station and an external sensor, which is known as extrinsic

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The design of the sensor makes use of optical fiber as a truly distributed temperature sensor with a spatial resolution

Optical Fiber Sensors: Working Principle, Applications, and Limitations

Light diffuser-based fiber optic sensor: a) Sensor fabrication process, b) fabricated probe, c) interrogation setup for

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Optical fiber sensor, with its particular advantages of small-size, anti-electromagnetic interference, chemical inertness,

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