NTC THERMISTOR PERFORMANCE IN ENVIRONMENTS WITH RADIATION EXPOSURE FAQs

WHY ARE NTC THERMISTORS EXPOSED TO RADIATION?

NTC Thermistors may be exposed to high levels of radiation for a variety of reasons.

- Medical patient monitoring probes are often sterilized using high doses of radiation to kill bioactive agents.
- Outer space environment applications in satellites and spacecraft may expose thermistors to extended periods of cosmic radiation or radiation from nuclear thermopiles.
- The nuclear industry may use thermistor based sensors in various processes for temperature control.

It is therefore desirable to understand the impact of various doses of radiation on the performance and reliability of thermistor based devices.

HOW ARE DISPOSABLE TEMPERATURE PROBES USED IN MEDICAL APPLICATIONS EFFECTED BY RADIATION STERALIZATION?

Disposable temperature probes from TE Connectivity (TE) for medical applications are often referred to as 400 Series or 700 Series (Thermilinear) thermistors. All disposable probes are sterilized at a minimum dosage of 2.5 Mrad (25kGy). Testing was performed at 5.0 to 8.0 Mrad (50 to 80kGy) during design development of both 400 Series and 700 Series thermistors. The results showed that performance of the parts was unaffected. Radiation sterilization has been a primary method in medical thermistor manufacturing for decades and has not been shown to cause reliability issues.

WHAT EFFECT DOES LONG-TERM RADIATION EXPOSURE HAVE ON NTC THERMISTORS?

A long-term exposure study was performed by Walter E. Chapin of OSU Nuclear Research Center. In this study, the 400 Series thermistors were exposed for three years in a nuclear reactor capable of 10 kW. The thermistors were subjected to gamma radiation levels of 7×10^8 ergs/gram (°C), 10^{15} neutrons per sq. cm of thermal flux and 10^{14} neutron per sq. cm of fast flux. The probes exhibited excellent stability, staying within 0.1°C of their original calibration. Additional testing under a weak flux region with a total exposure to fast neutrons of approximately $7 \times 10^{14} n/cm^2$ produced results showing no measurable change.

WHAT EFFECT DOES A HIGH RADIATION ENVIRONMENT HAVE ON NTC THERMISTORS?

TE was given the opportunity to study one of our high precision 44008 thermistors after use in a high radiation environment. The 44008 is factory calibrated to +/-0.1°C over the 0 to 70°C temperature range. This thermistor was used by Dr. Rod McDougall of The Radiation Therapy Department at the Mobile, Alabama Infirmary Medical Center. His application involved calorimetric measurements of patient radiation doses in cancer therapy. The thermistor was buried 3 cm deep in graphite and exposed to a total dosage of "150,000 rads at the X-ray energies of 6MEV, 18MEV and Colbalt 60, which is 1.25MEV effective" per Dr. Dougall's description. Recalibration after use showed that the thermistor remained in calibration across the entire interchangeable range.

ARE THERE NEGATIVE EFFECTS OF RADIATION ON NTC THERMISTORS UNDER HOSTILE ENVIRONMENTAL CONDITIONS?

A study was performed to determine if there would be any negative effects of radiation on thermistors under constant DC bias in a cold environment, such as is expected in space or polar applications. The high precision 44033 thermistor (±0.1°C from 0 to 70°C) was used in this test. Three 44033 thermistors were used, with one thermistor used as a control and not irradiated. All thermistors were pre-calibrated. The irradiated thermistors were connected in series with each other through a 1 MOhm resistor to a 4.3V supply during exposure to 2.3 x 10^5 roentgens. The thermistors were packed in dry ice continuously from the time irradiation began until they were recalibrated. Thermistor resistance measurements during irradiation indicated they were at approximately -55°C during this period.

These tests were run in air using a 12 kilocurie Co^{60} spatially extended source. Radiation received directly from the source was probably pure gamma rays since the covering on the Co^{60} blocks beta particles. Approximately 50% of the gamma rays had an energy of 1.17 Mev and approximately 50% had a 1.33 Mev energy level. The dose rate was approximately 2.3 x 105 roentgens.

As in the other studies no significant shift in calibration values was observed.

DOES RADIATION EXPOSURE HAVE AN EFFECT ON THERMILINEARS?

Thermilinear probes are special thermistor assemblies designed to provide an approximately linear response of resistance to changes in temperature. These assemblies utilize two different thermistors along with a fixed resistor network. Although thermilinears are essentially obsolete since the rise of microprocessors, these probes still find applications in legacy systems. They also provide a convenient platform for testing the effects of radiation on thermistors with different chemical compositions, and to check for overall impact on the resistor network. The most common thermilinears consists of a 6 KOhm thermistor with $Beta_{25/85}$ of 3976, and a 30 KOhm thermistor with $Beta_{25/85}$ of 3942.

Two of our thermilinear probes, models 44202 and 44203, were tested by Sandia Corporation in Albuquerque, New Mexico. Exposure to 1.09 x 10^{15} neutron dose and 8.2 x 10^5 gamma dose produced no detectable change in resistance.

DOES RADIATION HAVE AN EFFECT ON NTC THERMISTORS?

Repeated studies and extensive field history have shown that NTC thermistors are suitable for use in high radiation environments, exhibiting excellent stability and no degradation in performance.

Radiation, either Gamma or X-ray, is suitable as sterilization method for both 400 series and 700 series thermilinear networks.

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