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A RUGGED PORTABLE COLLIMATED GAMMA RADIATION DETECTOR

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Introduction

A rugged, portable, collimated gamma radiation detector for field use was developed. It was required that the detector will withstand severe environmental conditions such as rain, humidity, shocks and vibrations.
The detector includes: 2" x 2" hermetically sealed CsI(Tl) scintillation detector optically coupled to a 2" diameter photomultiplier tube (PMT), and appropriate electronic circuits. The pulse from the detector is transferred to a multi channel analyzer card installed in a computer, to enable data acquisition spectrum and analysis.
The detector is wrapped by three protection layers: A μ-metal shield protects the PMT from undesirable influences of magnetic fields; a lead collimator tube decreases cosmic and background radiation influences, and identifies exactly the radioactive source direction; a 1mm copper layer decreases X-ray absorption from the lead collimator.
The main environmental conditions tested were: water resistance, vibration, and mechanical shock.
Water resistance - The detector must operate underwater at a depth of 15 cm for 30 minutes.
Vibration - 30 minutes duration, at frequency range of 0-500 Hz and overall Grms level of 0.74.
Mechanical shock - One meter drop on a wooden floor.
Since the sensor and the PMT are very fragile and most sensitive to mechanical shocks, the one meter drop on a wooden floor is the most complicated test. A double protection system was designed to withstand this test. The first is a special carrying bag to reduce the main shock created by the drop test. The second is a floating structure to isolate the sensitive sensor and the PMT from the lead shield.

Environmental Tests

To test the influence of the shock protection system and determine the adequate foam materials and their thickness, several controlled drop tests were conducted. The main target was to reduce the shock conveyed to the sensor, under the permitted level according to the manufacturer requirements. In order to save the expensive sensor, a dummy has been manufactured with identical weight and dimensions. A tri-axial accelerometer attached to the dummy, measured the shock levels transferred to the sensor. The detector was also tested with an electrodynamic shaker to ensure vibration endurance.

Main Mechanical Modules

Detector Housing

The detector housing, an aluminum tube, has been designed to protect the sensor and to support the lead collimator. The scintillation detector and PMT were assembled in a floating structure made of 10 mm thick cellular urethanes foam that absorbs repeated impacts and vibration energy.
One of the requirements was to enable the collimator removal without tools. This was achieved by sliding the lead collimator to its place on three o-rings that surround the tube. Optimization of the friction factor allows on the one hand easy removal of the collimator, and on the other hand to hold the lead collimator vertically. The tube is sealed by a 1 mm aluminum welded cover.

Electronic Circuits Case

The case consists of two PCB's including the appropriate electronic circuits. The case is made of an aluminum rod that matches smoothly the detector tube. Part of the rod is shaped as a square case for the electronic circuit. The case top surface has been fine machined to ensure hermetic sealing with the battery case, using a silicon gasket.

Battery Case

The aluminum battery case contains two rectangle 9V batteries. The battery case is used also as the lid for the electronic circuits case. Part of the case is an operating panel that includes a sealed indication LED lamp and a sealed connector. The LED indicates battery power and flickers according to the detector pulse rate. The connector is used to transfer a pulse from the detector to the computer, and functions also as an on/off switch; the detector starts operation only when the cable is connected to the connector for the purpose of prolonging battery life time.

Finish Processing

All the case external surfaces were machined to be highly smoothed in order to improve sealing and aesthetics. The conductive conversion treatment provides both, corrosion protection and electronic conductivity for the EMI shielding.

Collimator

The collimator is constructed of two layers. The outer layer is a lead tube. The inner layer is a 1mm thick copper tube that is pressed into the lead tube.
A dummy P.V.C. collimator, with the same dimensions as the lead one, was designed to enable proper fitness of the detector in the carrying bag when the lead collimator is not required.

Padded Carrying Bag

A special carrying bag was designed in order to reduce the shock resulted from unintentional falling. In addition, the bag is used for carrying the detector, the collimator and accessories such as spare batteries, cable, screwdriver, and storage protective covers. The bag external coating is made of water resistant plastic whereas the internal layer is made of water resistant foam. The foam is used as a shock absorbing material tested to withstand fallings from 1 meter. It is built as a combination of firm and soft foam layers, to achieve the mechanical design requirements. A carrying wide strap, fixed according to the gravity center, keeps the assembled carrying bag in balance while it is carried on the operator's shoulder.

Summary

The collimated gamma radiation detector was tested in various environmental severe conditions and satisfactory results were obtained.