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#07-142 Ruggedized High Purity Germanium Detectors for in-situ Gamma Spectroscopy

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This paper presents the design and performance of turnkey and compact HPGe solutions, developed by Mirion Technologies (CANBERRA) for radionuclide identification outdoor and under harsh environmental conditions. Surveys can be undertaken under various weather conditions, in contaminated areas, underground or immersed under water (sea, rivers, pools), with fast on-site deployment and without compromising the performances and reliability experienced with laboratory-grade HPGe instruments.
In situ measurement is a privileged way of detecting radioactive contamination compared to analyzing samples in a distant, specialized laboratory. On the other hand High Purity Germanium (HPGe) spectrometers provide unmatched nuclide identification capability with the lowest minimum detectable activities thanks to its excellent energy resolution and high stopping power. However, HPGe instruments are not always of practical use on the field (because of the liquid nitrogen, weight and bulkiness).
These systems relies on advanced technologies such encapsulating the HPGe crystal under ultra-high vacuum (UHV), different low vibration electrical cooler adapted to the crystal size, and advanced digital spectroscopy processor. Besides, their design includes hardened pressure housing, minimization of footprint and weight, sealing and water-tightness allowing easy cleaning from dirt or contamination.
Several examples of such ruggedized HPGe detectors will be described, illustrating the wide new range of applications permitted by these technologies: they are respectively designed for borehole measurement, high efficiency spectrometry from an aircraft or other vehicles, in situ sea and river contamination monitoring, as well as an ultra-compact detector for D&D or high count rate environments.
The sealed probe is an assembly consisting of a 80 mm in diameter shock proof and watertight external housing, including a 20% relative efficiency HPGe crystal mounted in an ultra-high vacuum (UHV) cryostat (CANBERRA proprietary technology) along with a compact cryocooler. A detailed view of the probe is shown in Figure 1.
The UHV encapsulation of the HPGe crystal allows partial thermal cycling without harming the crystal and degrading the detector performances, thus extending the life of the detector. The HPGe crystal cooling relies on a new compact inline cryocooler, operated with active vibration reduction in order to keep the excellent intrinsic crystal energy resolution. This technology allows an increased portability, smaller footprint and safety of operation without the use of any flammable gas. It is also maintenance free and the reliability has also been probed with a large MTBF.
Higher efficiency versions of water tight detectors have also been designed and manufactured for continuous monitoring of contaminants in rivers, lakes or sea water (Figure 2). Such configurations can accept germanium crystals of several kg and relative efficiencies in excess of 100%). As the sealed probe, the heat generated by the electrical cooler is dissipated passively through the outer housing of the detector. A full set of monitoring and readout equipement and software is also provided.
These systems provide solutions to perform high resolution gamma spectroscopy similar to the performance achieved in laboratories with regular High Purity Germanium detectors (HPGe), but where no current products are compact or robust enough to be installed.
They features a FWHM of 2 keV at 1.33 MeV, 1.7 keV at 662 keV and below 1 keV at 122 keV. A

complex mixture of nuclides can therefore be analysed in order, for instance, to distinguish anthropogenic radioactive sources from natural ones. The excellent resolution also allows for a significant increase in the minimum detectable activity (MDA), 3 to 5 times higher than scintillator-based detectors of similar sizes. For instance, simulations lead to a MDA of Cs-137 in water of less than 0.5 Bq / L for 600 seconds acquisition time.

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