Search And Identification of Nuclear Materials with Handheld Instruments for Security and Safety Purposes

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Introduction

The search for illicit trafficking or hidden radioactive materials was already important since the breakdown of the former Soviet Union. The menace of terrorism has now generated even more interest in this field.
Any penetrating type of radiation like photons or neutrons can hardly be shielded. Sensitive instruments for neutrons or gamma rays are therefore well suited for the search, localization and identification of radionuclides.
Especially neutrons are very penetrating and they are also always indicating dangerous situations. A few materials like for instance plutonium show spontaneous fission processes with neutron emission. The intensities are sufficient to detect macroscopic amounts of plutonium within very short time even through massive shieldings. As the natural neutron background is extremely low, minimum detectable amounts are also very low.
Gamma spectroscopy is the best method for the identification of radionuclides. Since the development of battery operated handheld instruments with automatic spectral analysis and nuclide identification even unskilled users can easily obtain fast and reliable information in the field.

The Plutonium Monitor LB 6414

Berthold Technologies has developed a new neutron survey meter which is optimized for the detection of fission neutrons. The sensitivity is sufficiently high to detect macroscopic amounts of plutonium within a few seconds. The detection system uses a large ^{3}He proportional counter tube within in a moderator made out of polyethylene. The measuring electronics UMo LB 1230 indicates the counting rate on a display. The total weight of the battery operated instrument is about 4 kg.
Measurements with several Plutonium samples with known isotopic composition and masses between 100 g and 1000 g had been performed at the EURATOM in the Research Center Karlsruhe in Germany.
The instrument's fluence response to fission neutrons was determined to be 26.4 cm^2. With a measuring time of 10 s at a distance of 1 m the detection limit for reactor plutonium was found to be only 10 g. Under the same conditions for weapons plutonium with fewer neutrons emitted the detection limit is 47 g.
The response to ambient neutron background is approximately 0.06 cps. The intrinsic background is much lower and was measured in a shielded laboratory 46 m below ground. The rate was 0.006 cps at a total neutron flux $< 2 \times 10^{-4}$ $cm^2 s^{-1}$.
The LB 6414 was certified in the ITRAP test by the Austrian Research Center Seibersdorf/IAEA.

The Nuclide Identifier LB 125

In applications in nuclear medicine, research, authorities, customs, police, military, fire brigades but also in transport of nuclear materials, nuclear decommissioning and waste, in steel industry and scrap there are sometimes unidentified radionuclides
Gamma spectroscopy provides an excellent tool for the identification. The handheld gamma spectrometer LB 125 uses a 1.5" x 1.5" NaI cristal as detector and a fast multi-channel-analyzer with 512 channels and low power consumption. Maximum operation with rechargeable batteries is 8h.
It has 4 operation modes: spectrum, dose rate, search and an automatic mode for unskilled users.
The spectrum mode offers cursor, region of interest, peak analysis, nuclide library with more than 90 nuclides, nuclide identification and memory for up to 30 spectra. Energy calibration can be performed with an external 9 kBq ^{137}Cs source. The instrument also reports the type of radionuclide after identification: industrial, medical, natural and nuclear.
In dose rate mode the instrument uses pulse height analysis to determine the ambient dose equivalent H*(10). The measuring range is between 10 nSv/h and 100 µSv/h. As the instrument has a very high sensitivity it is ideal for the localization of hot spots with dose rate threshold alarm.

Summary

The detection and identification of nuclear materials is of increasingly importance not only since several cases of nuclear smuggling had been reported. For instance the theft of plutonium in Karlsruhe by an unauthorized person indicated that gates of nuclear facilities might not be sufficiently protected.
■ Detection of fission neutrons is a sensitive tool for plutonium search
■ NaI gamma spectroscopy based on cheap and efficient technologies and with intelligent software solutions provides nuclide analysis even for unskilled users

References

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