CANBERRA

D&D Capabilities and Solutions

Remotely Operated Systems for Underwater Measurements

Key Drivers:

During a D&D project, underwater measurements are usually required in several situations such as defueling the reactors and the storage pools, legacy waste stored in ponds, and contaminated natural sites (rivers, ponds, sea….).

Underwater nuclear measurements usually have a lower accuracy than 'in air' as the water has a higher attenuation on gamma energy and the sample characteristics can be more challenging.

SMOPY and ROVING BAT systems have been developed for underwater measurement in the application of activated waste characterization, concrete wall, or reactor component characterization.

- **Safety:**
  - Control safety risks for the shipment of the waste to the temporary storage facility.
  - Ensure the waste activity level remains in the range allowed by the design of the storage facility.
  - Control of the critical risks of nuclear materials and waste.
- **Safeguards:**
  - Declare the fissile masses and nuclear material activities to Authorities and to the National Agency of Radioactive Wastes for costs and scenario forecasts for future final storage.
- **High activity nuclear waste:**
  - Measure the actinide, fission products isotopes and mass.

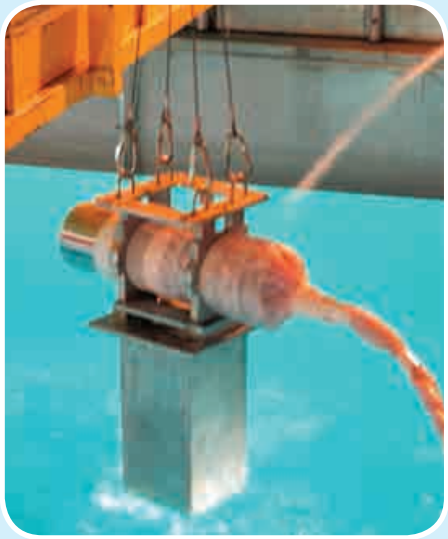
KEY BENEFITS

- Dose reduction (ALARA Principle)
- Accurate segregation of waste / storage of spent fuel
- Cost reduction for shipment & storage
- Environmental impact

Objectives:

Mirion has advanced experience in providing high performance detectors combined with remote systems.

- Characterization of spent control rods from decommissioning nuclear plants before they are packaged, shipped and stored as intermediate-level radioactive waste.
- Localization and characterization of contaminated hot spots and areas on underwater walls and soils.



A CANBERRA™ solution can be customized based on the unique requirements of the situation. *All the solutions offered in this flyer can be thoroughly performed by our Measurements & Expertise (M&E) team, without any purchase of products or systems.*

MIRION TECHNOLOGIES

Remotely Operated Systems for Underwater Measurements

Remote systems

Fixed angle underwater monitoring system

Technical description

- The fixed angle underwater monitoring system can be suspended by a crane to measure the gamma spectrum along a cask filled with activated waste (see figure below).

Key benefits

- Simple to manipulate.
- Underwater gamma spectrometry measurements with good spatial and energy resolutions.
- Various types of CZT detectors can be selected so as to address a large range of highly radioactive wastes.
- Coupling gamma and neutron measurements in a single compact device.
- Dedicated software allowing various measurement sequences.

Remote underwater 3D free angle measurement

The figure below shows the ROV equipped with a Gamma Spectroscopy System.

- Operation down to 200 m.
- Contamination measurements in sediments.
- LaBr probe with countermeasures to handle water column shielding issues.
- USBL cable for controlling the detector for position underwater from the boat.

Detectors calibrations inside the remote system is carried out in a dry situation and inside the pool or sea. The samples are well known and quantified such as concrete, ^{60}Co, etc...

Underwater HPGe probes

Sealed detectors for ultimate underwater spectroscopy measurement

Technical description

- The Canberra sealed probe system consists of a 20% efficiency coaxial HPGe detector encapsulated in an Ultra High Vacuum (UHV) cryostat. The standard configuration includes an IP68 pressure housing which can be adapted to the user's applications (for example thickness and material customized to the water depth, reinforcement on the front to withstand borehole applications). The overall probe diameter is 80 mm and weighs less than 10 kg.

  A ruggedized cable, which is easy-to-clean and easy to decontaminate is attached to this probe through a watertight connection. The cable length is possible up to 100 m.

  This cable is connected to an acquisition station including controllers and a Canberra Lynx® DSP; the station can be located at the surface or close to the detector if needed.

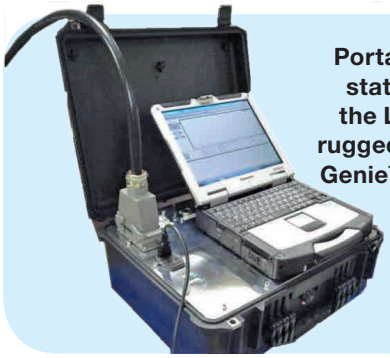
Application examples

- Reactor storage pool, for spectrometry.
- Outside operation, where water is present such as under the rain, in borehole with mud or ground water layers crossing, for environmental contamination surveys or D&D.
- Into the sea, for oceanography or physics experiments, with the detector being stationary (buoy) or hooked on a boat.
- Borehole logging measurements.

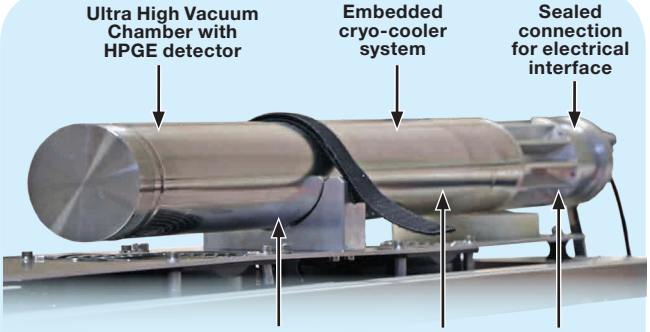
Key benefits

- The cryogenic cooling technology has evolved to achieve the highest degree of compactness and reliability.
- Cooling down time is less than 8 hours.
- The UHV encapsulation allows incomplete thermal cycles. Unlike laboratory HPGe detectors, the sealed probe system can be cooled down at any time regardless of the temperature of the HPGe detector, greatly reducing the down time in operation.
- Performances similar to lab conditions.
- Easy to clean from dust, contamination, or shells.

Example of the probe immersed in a transparent water tank and connected to a 25 m composite cable



Portable acquisition station containing the Lynx DSP and a ruggedized laptop with Genie™ 2000 software



The modular design of the probe allows easy customization and maintenance

Applications

Fuel debris measurement with neutron detector and/or gamma spectrometry

Technical description

Mirion provides a large range of techniques to characterize fuel debris.

Those techniques are able to quantify uranium and plutonium, as well as fission and activation products. Most common fuel or high level waste measuring systems are a combination of gamma spectrometry and neutron measurement.

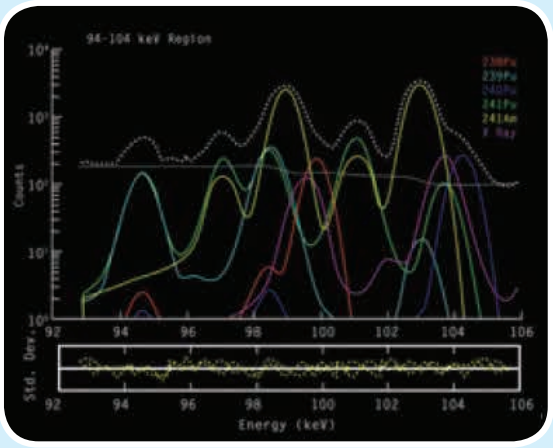
Gamma Spectrometry:

- Several of the Isotopes present in the fuel have specific gamma energies that can be detected and quantified thanks to gamma spectrometry. Some of the Uranium and Plutonium Isotopes emit gamma rays in the low-medium energies, whereas major Fission and Activation products emit gamma rays in the medium to high energies.
- **For Uranium and Plutonium Isotopes,** specific algorithms have been developed for the determination of U and Pu isotopic ratios based principally on the low energy peaks (but using the medium energy peaks under some conditions). Gamma spectra can be analyzed using Multi Group Analysis (MGA) and (MGAU) or FRAM software.
  - Relative Plutonium and Uranium isotopic concentration.
  - Determine other actinides such as ^{235}U, ^{239}U, ^{237}Np and ^{241}Am.
- **For Fission and Activation products,** standard spectrometry gamma analysis is performed using either standard Genie 2000 software or NDA 2000 software.
- **For Isotopes that cannot be measured directly,** it is possible, if fuel data are available (from depletion code), to determine them using correlations between Fission products directly measured and the Isotopes in question. Detector to be used could be HPGE with collimators and screen if high resolution is required or CZT type if precision is not required.

Neutron Detection

- Typically fission chamber or ^{3}He proportional tubes, providing high neutron detection efficiency.
- Give the neutron profile of the fuel debris.
- Determine ^{240}Pu effective mass by fission neutrons detection in Totals or Coincidence mode.

Example spectrum fitting from MGA isotopics analysis software



Among our products, several kinds of probes, detectors and monitors are available for underwater measurement.

We successfully deployed HPGe and neutron detectors into underwater detection systems such as those shown in previous pages, and we can provide solutions for many challenging underwater nuclear measurement applications.

For any case when measurements must be taken in extreme conditions, a feasibility study is required to identify the advanced hardware, software solutions that are appropriate for each situation. During the feasibility study, our experienced team will evaluate the specifics of the situation and confirm the optimal approach.

Applications

Characterization of concrete wall in a pool using ROVING BAT

Accurate nuclear measurement with a ROVING BAT

Technical solution

- Standard ROVING BAT (high-end submarine able to crawl on the pond wall) equipped with specifically designed probe (CZT), and linked to Genie 2000 software via a Canberra electronic system.
- Coupled to an algorithm calibrated with past experience and core sampling to calculate depth-profile.

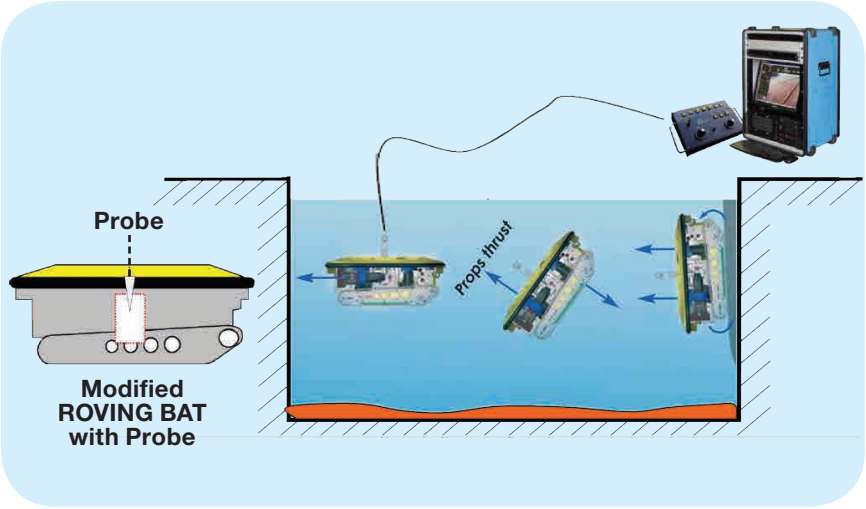
Radioactivity mapping

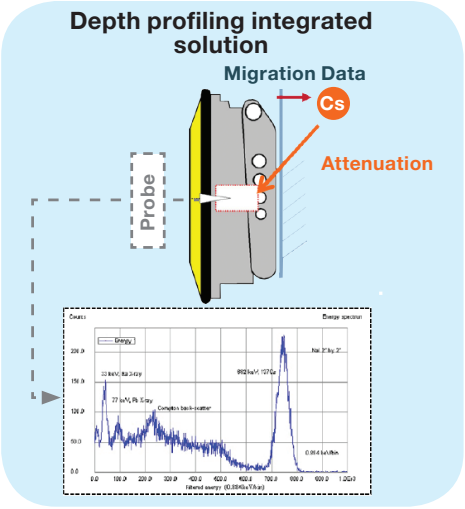
- Mapping of the contamination on the pond walls is essential for capturing the regions to decontaminate.
- 3D radioactive mapping enables a precise waste generation during scrabbling.
- Performed by krigeage method with standard software.
- Specific expertise in krigeage results analysis.

Contamination depth-profile

- Migration of radionuclides in concrete walls is the main concern as it is not visible with a regular nuclear measurement.
- Based on first-hand experimental operations on pond, an algorithm to capture migration was developed during a nuclear measurement.
- Knowing the contamination depth-profile of the pond walls, accurate scenarios can be prepared for precise scrabbling.

For an accurate measurement, the system can be customized by inserting the ISOCS™ instrument or other detectors inside the ROVING-BAT depending on the application.





Remotely Operated Systems for Underwater Measurements

D&D Capabilities and Solutions

Successful achievements

Characterization of the Medium/High active waste in a pool before disposal using SMOPY (Safeguards MOx PYthon) device

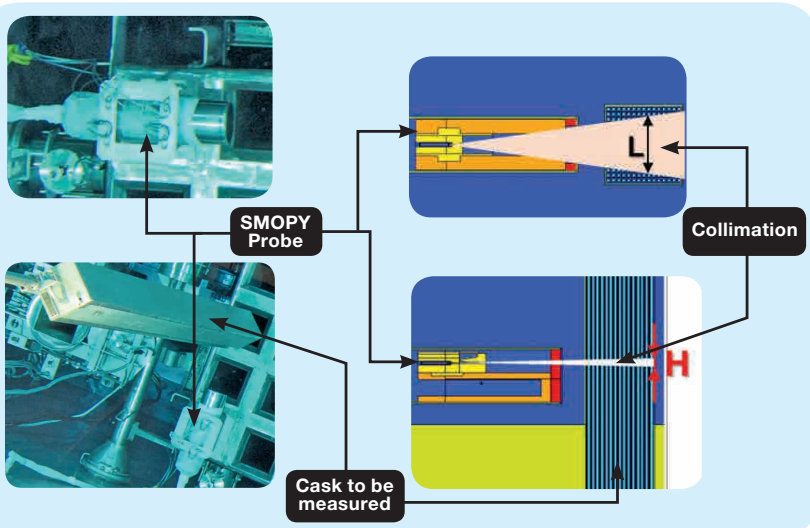
Objectives:

- Storage space is needed in the storages pond of NPPs.
- Improved waste characterization data is needed to allow movement out of pond.
- Measurement of control rods to be shipped in a new facility (storage for activated waste)
  - Profile of activity of ^{110}mAg, ^{108}mAg and ^{60}Co
  - Total activity
  - Absence of fissile material in the casks through neutron measurement
- Casks filled with 150 to 230 control rods.
- Feasibility study: various protocols are tested and method was deployed to provide the characterization data.
- Collimation enables accurate measurement of a layer of around 2 cm to 5 cm high, and a scanning of the cask provides a full activity profile.

Mirion Solution:

- A CZT detector for gamma spectrometry, a fission chamber for neutron detection, and a portable MCA with Genie 2000 sofware.
- Determination of the total activity and the activity profile by gamma spectrometry.

Nuclear facility pool storage



For more information, review the complete case study on our website:
www.canberra.com/measurements-expertise

Radiation Safety. **Amplified.** **www.canberra.com**

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C49117 – 06/2016