International Nuclear Safeguards Solutions

NUCLEAR MEASUREMENT SOLUTIONS FOR SAFETY, SECURITY & THE ENVIRONMENT

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CANBERRA

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Detection Technology Protecting A Changing World

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RadGuard

CANBERRA is committed to providing radiation measurement solutions to the worldwide safeguards community that meet or exceed your unique requirements. Through our partnership with safeguards planners and engineers, CANBERRA gains an in-depth understanding of your needs and applies best technologies and design practices to create specifically-tailored solutions.

The RadGuard™ family offers products, systems and services for safeguards applications.

- **non-destructive analysis**
- **unattended monitoring**
- **containment and surveillance**
- **remote monitoring**
- **destructive analysis**
- **environmental sampling**
- **data security**

Fuel Pellets, FBFC Romans (France)

The RadGuard family delivers unmatched quality, accuracy, reliability and reproducibility designed to exceed our customers' expectations. These solutions are developed and supported by a staff with extensive and diverse experience in this field, ranging from inspector support to nuclear safeguards research.

RadGuard represents CANBERRA's deep commitment to the continual evolution of solutions for the ever-changing demands related to safeguarding special nuclear materials — *Detection Technology Protecting a Changing World.*

CANBERRA

CANBERRA Nuclear Safeguards

Experience in Safeguarding Special Nuclear Materials

Effective international safeguards requires experience, reliability, reproducibility, worldwide support and an understanding of the unique needs of and difficulties faced by inspectors. CANBERRA has specialized experience in measurements of fissionable material and containment verification and surveillance, as well as the resources to support ongoing development based on evolving requirements.

Key Collaborations

CANBERRA's commitment to safeguards goes far beyond building and supplying equipment. CANBERRA has ongoing collaborations with international safeguards agencies and with the laboratories that pioneer new measurement, sealing, and surveillance techniques. Long-standing relationships with these organizations have resulted in the rapid commercial development of leading-edge technologies as well as the prompt assimilation of updated requirements into CANBERRA instrumentation and software. CANBERRA has an established relationship with the European Safeguards and Research Development Association (ESARDA), and a sustaining membership in the Institute of Nuclear Materials Management (INMM).

Technology Evolution

From early on, CANBERRA has been a supplier of NDA instrumentation to safeguards authorities. Initial safeguards measurement efforts concentrated mostly on portable non-destructive assay (NDA) equipment and containment verification. The focus was on gamma and neutron measurements because they were able to identify and quantify most forms of nuclear materials that were of concern at the time. However, such instrumentation has evolved from simple gross measurements to highly sophisticated spectroscopic isotope identification systems using gamma detectors, and from gross neutron measurements to multiplicity neutron counters.

Surveillance Systems

Besides gamma and neutron measurements, the safeguards community has made extensive use of containment (seals) and surveillance (cameras). CANBERRA has had a major role in developing dedicated safeguards systems for these types of devices. Such systems are designed to be highly reliable, power-independent, data-secure and tamper-indicating, as they often reside in hostile environments.

Receiving Plutonium. Melox, MOX Fuel Manufacturing Plant

> ***The RadGuard family delivers unmatched quality, accuracy, reliability and reproducibility designed to exceed our customers' expectations.***

Reliable and Reproducible Measurements

As a safeguards measurement has international ramifications, it must be accurate, duplicable and verifiable. CANBERRA data acquisition systems utilize computer-controlled setup parameters that can be automatically downloaded from predetermined, password-protected measurement regimes. This provides assurance that the measurement is correct. Measurement parameters and analysis sequences are recorded in our unique CAM file, assuring reproducibility. If an anomaly is observed in a measurement, all data, setup and analysis parameters are stored together to allow for comprehensive data review.

Quality

CANBERRA equipment meets ISO 9001 and CE standards, and the company holds appropriate certifications in all countries and regions in which we operate. Certificates can be obtained by contacting your local sales or service office. CANBERRA measurement services are performed under stringent QA programs including NQA-1 and DOE order 830.120.

Global Support

Our commitment does not end with the delivery of advanced, high-quality measurement solutions. Ensuring long term success in field operations requires nothing less than a well-established, global support network. CANBERRA operates manufacturing facilities in Europe and the United States and has subsidiaries throughout the world providing sales, service and value added services. Our network of distributors with extensive sales, service and support capabilities spans sixty countries. In areas with major safeguards activity, extensive application support and training is also available.

International Safeguards Summary Including Joint Use Equipment and Seals & Surveillance

Application	Type	Model	Page
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Facility/Equipment Cross Reference

IAEA Defined Facilities	NDA Systems	Surveillance & Seals	IAEA Application
Enrichment Plants	PMCN/PMCG	Surveillance: ALIS, ALIP, DSOS, SDIS, NGSS Seal: EOSS, RMSA	UF6
Fuel Fabrication Plants	High Enrichment - KEDG/HKED, PMCN/PMCG, AWCC, UNCL, INVS, HLNC, PIMS, PNCL, UFBC, PSMC, WDAS, Shuffler, Slab Counters; Low Enrichment - PMCN/PMCG, AWCC, UNCL, HLNC, FDET, Shuffler	Surveillance: ALIS, ALIP, DSOS, SDIS, NGSS Seal: EOSS, RMSA	U and Pu Oxides
Power Reactors and Storage Facilities	PNCL, PMCN/PMCG, SFAT, AWCC, HLNC, FDET, PMCN/PMCG, SFAT, HRGS, PMCN/PMCG, PNCL, HRGS, AWCC, PNCL, UNCL, UFBC, PMCN/PMCG, SFAT, MiniGRAND (MGBS)	Surveillance: ALIS, ALIP, DSOS, SDIS, NGSS Seal: EOSS, RMSA	Spent Fuel
Spent Fuel Reprocessing Plants	AWCC, INVS, HLNC, Glovebox Counter (OSL), PNCL, URM, PMCN/PMCG, KEDG/HKED, U/Pu InSpector, SFAT, WDAS, Slab Counters, Shuffler, SGS, MiniGRAND (MGBS)	Surveillance: ALIS, ALIP, DSOS, SDIS, NGSS Seal: EOSS, RMSA	U and Pu Nitrates

Non-Destructive Analysis

CANBERRA gamma assay, neutron assay, and combined gamma/neutron systems are available to measure containers. Process knowledge or laboratory analysis of the isotopic inventory of a particular stream can be utilized to provide scaling factors for pure alpha and beta emitting nuclides which cannot be measured directly.

Gamma Ray Spectrometry

Hybrid K-Edge/XRF Analyzer

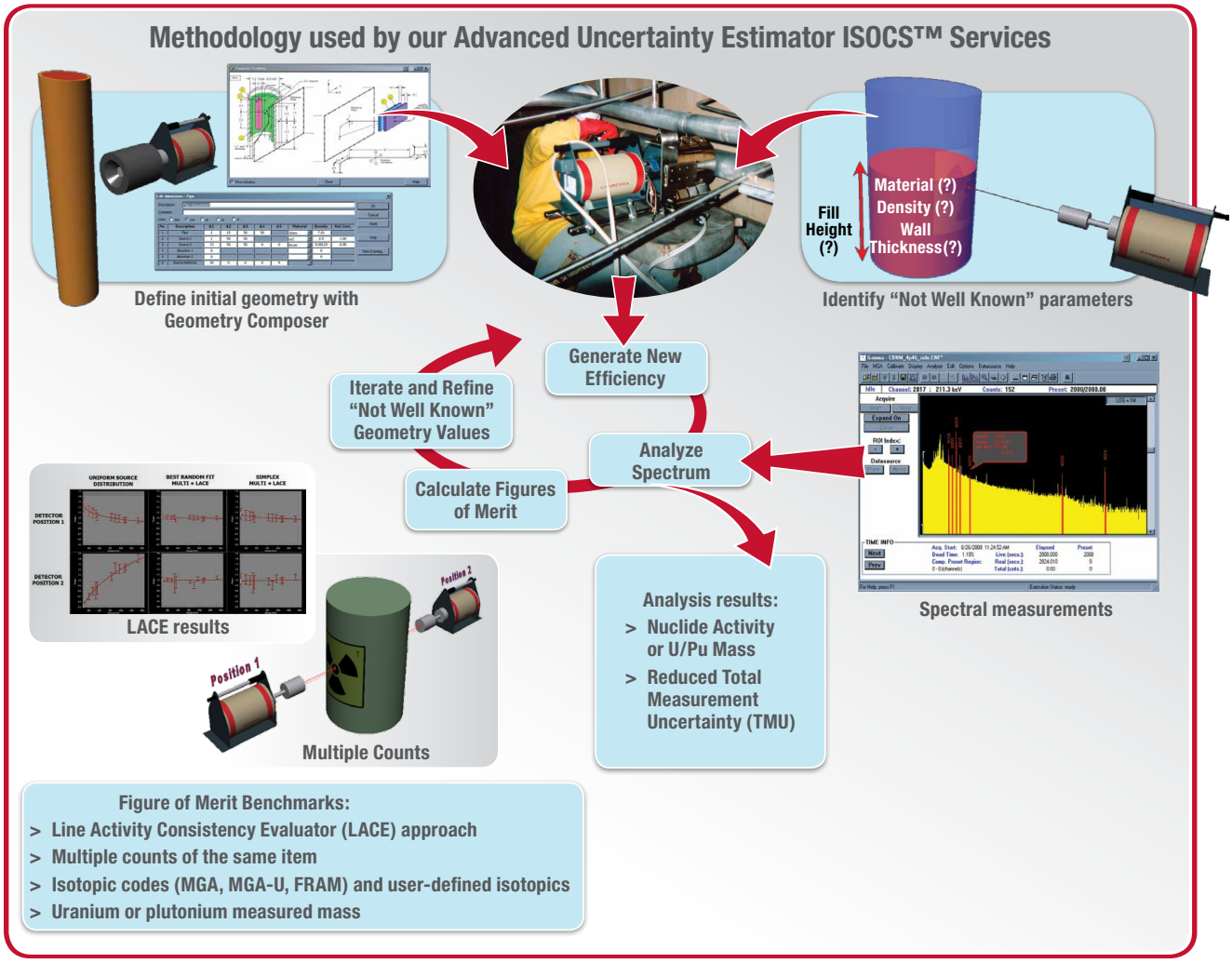
- Authorized for routine inspection use by the International Safeguards Community as the HKED and KEDG
- Non-destructive on-site analysis of heavy elements in a wide variety of materials, including highly radioactive samples
- Analysis for several elements simultaneously
- No sample preparation required
- Only 2 mL of the sample material is required
- Precision typically better than 0.5%
- Typical assay time of 5 to 20 minutes

Hybrid K-Edge/ XRF Analyzer

ISOCS™: In Situ Counting System

- Immediate, accurate, nuclide-specific results for field measurement of any object or surface
- Sourceless detector-specific calibrations generated by software as the sample is being counted – simply enter source/collimator/detector position dimensions
- Calibrations generated for any object/surface that can be approximated by plane, cylinder, box, sphere, well/ Marinelli or pipe
- Mobile detector positioning device includes 25 mm and 50 mm collimators and backshields, and accommodates any detector orientation
- Complex pipe template allows modeling of complex, multi-layer pipes and drums
- ISOCS Uncertainty Estimator tool (IUE) helps minimize uncertainty and improve results


ISOCS™: In Situ Counting System



Advanced ISOCS™ Uncertainty Estimator Services

- Combines a reliable and time-proven ISOCS™ based efficiency calibration to help reduce TMU in quantifying radionuclide activities or masses inside "Not Well Known" containers.
- Directed & automated optimization using numerical methods
- Simplified and field-driven user input option, with customized setup files.
- Applicability in Safeguards, Materials Accountancy, Decommissioning and Decontamination, Non-Destructive Assay systems and Nuclear Reactor Outages Maintenance
- Developed in close collaboration with the International Safeguards Community
- U.S. Patent granted (13/674,649)

Non-Destructive Analysis

Gamma Ray Spectrometry

Continued

U-Pu InSpector

- An integrated, portable instrument to measure the isotopic composition of plutonium or the enrichment of uranium without prior efficiency calibration
- Comes standard with special LEGe detector:
- Optimized for high dynamic activity range
- Built-in high Z collimator shell with filters
- Multi-Attitude Cryostat, two day holding time
- Quick and easy filling with special fill device
- System carrying case
- U-Pu Software – The U-Pu system can be operated with standard MGA and/or MGAU software to obtain plutonium and uranium results respectively. A separate top-level custom interface exists that communicates with MGA & MGAU. This can be provided if requested.
- Optional EXTERNAL COLLIMATOR that is only required for High-count-rate applications (> 50,000 counts/sec).

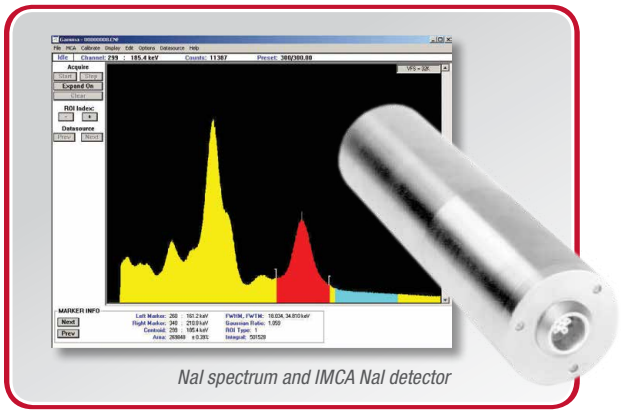
InSpector Multichannel Analyzer (IMCA)

- Provides measurement/confirmation of uranium enrichment using the enrichment meter technique
- Based on Brookhaven/Los Alamos designs for use by the International Safeguards Community
- Provides complete functionality of IAEA PMCN* and PMCG** procedures
- Available with following detector types:
  - ^{241}Am seeded NaI(Tl) detector (both characterized and uncharacterized for temperature drift)
  - Normal NaI(Tl) detectors
  - HPGe detectors (typically same as the U/Pu InSpector)

Available in general user or special International Safeguards Community format

* Portable multichannel analyzer with NaI detector (IAEA/SG-NDA 5)

** Portable multichannel analyzer with HPGe detector (IAEA/SG-NDA 13)



NaI spectrum and IMCA NaI detector

Neutron Counting

CANBERRA offers several neutron counters that utilize coincidence and multiplicity techniques to assay a variety of material types in different sized containers. The counters include passive and active neutron systems.

IAEA Authorized System code	IAEA System Title	CANBERRA Product Number
AWCC	Active Well Coincidence Counter	**JCC-51**
HLNC	High Level Neutron Coincidence Counter	**JCC-31**
INVS	Inventory Sample Coincidence Counter	**JCC-12/JCC-13/JCC-14**
NCCE	Neutron Coincidence Counter Electronics	(See Unattended Monitoring Section page 18)
PNCL	Plutonium Neutron Collar	**JCC-71**
PSMC	Plutonium Scrap Multiplicity Counter	**PSMC**
PWCC	Uranium Neutron Collar	**JCC-71/ JCC-72/ JCC-73**
UFBC	Universal Fast Breeder Counter	**JCC-61/JCC-62**
UNCL	Uranium Neutron Collar	**JCC-71/ JCC-72/ JCC-73**
WCAS	Waste Crate Assay System	**WCAS**
WDAS	Waste Drum Assay System	**WM3100**

Some of the counters listed above as well as additional neutron counter types are shown on the following pages.

Passive Neutron Coincidence Well Counters

Models Available: JCC-12, JCC-13, JCC-14, JCC-31, JCC-41, JCC-51, JCC-61, JCC-62, JCC-71

- Sample cavity – varies with model number
- Developed for passive measurement of plutonium inventory samples (powders, pellets and liquids)
- Designed for the safeguards community for on-site verification measurements, particularly, at reprocessing and Pu facilities
- Measures ^{240}Pu content by counting coincidence fission neutrons
- Mass range from 0.1 g to hundreds of g of plutonium

Non-Destructive Analysis

Neutron Counting

Continued

Active Neutron Coincidence Counters

Models Available: JCC-51, JCC-71, JCC-72, JCC-73

- Sample cavity – varies with model number
- Developed for active measurement of ^{235}U inventory samples (powders, pellets and fuel assemblies)
- Designed for the safeguards community for on-site verification measurements, particularly, at reprocessing and uranium facilities
- Uses Am(Li) alpha-n neutron sources to interrogate the sample
- Measures ^{235}U content by counting coincidence neutrons from induced fission events
- Mass range from 0.1 g to hundreds of g of uranium

Neutron Multiplicity Counters

Models Available: JCC-51, PSMC, LEMC*

- Developed for passive measurement of scrap materials containing plutonium
- Designed for the safeguards community for on-site verification measurements particularly at reprocessing and Pu facilities
- Measures ^{240}Pu effective content by counting coincidence fission neutrons, but corrects for self multiplication effect by use of three neutron coincidences.
- Mass range from 0.1 g to hundreds of g of plutonium

* LEMC – Large Epithermal Multiplicity Counter

WM3400 Neutron Slab Counter

Neutron Slab Counter

- Go/no-go screening of gram quantities of plutonium in 200 L drums
- Variations of the Neutron Slab Counter can be used to measure holdup in gloveboxes, pipes, pumps, etc.
- Transportable to allow positioning in front of the drum
- Easy operation with minimal operator training Neutron Drum and Crate Slab Counter
- Quantification and screening for plutonium in drums or crates
- Transportable to allow easy repositioning around different size samples
- Easy operation with minimal operator training

Cf-252 Passive/Active Shuffler

- Active interrogation of fissile isotopes in 200 L drums
- Passive measurement of the even isotopes of plutonium
- Fast/Thermal interrogation for reduced self-shielding effects
- Add-a-source option for matrix correction
- Counter efficiency: 17.5%
- MDA's as low as:
  - 24 mg ^{235}U in thermal active mode
  - 300 mg ^{235}U in epithermal active mode
  - 3 mg ^{240}Pu-effective

Non-Destructive Analysis

Neutron Counting

Continued

Neutron Drum and Crate Slab Counter

- Quantification and screening for plutonium in drums or crates
- Transportable to allow easy repositioning around different size samples
- Easy operation with minimal operator training

WDAS Passive Neutron Waste Counter

WDAS Passive Neutron Waste Counter

- Passive Neutron Drum Counter
  - Improved automation capability
  - Ease of integrating optional gamma isotopic station
- Quantification of plutonium in 200 L drums (smaller version available for 100 L drums)
- Transuranic/low level waste classification
- Add-a-source option for matrix corrections
- The passive neutron waste counter can be extended for crates and boxes of all sizes (WCAS)

Flat Squared Neutron Coincidence Counter

Well-type passive counter for in-plant measurement of plutonium samples ranging from milligrams to kilograms

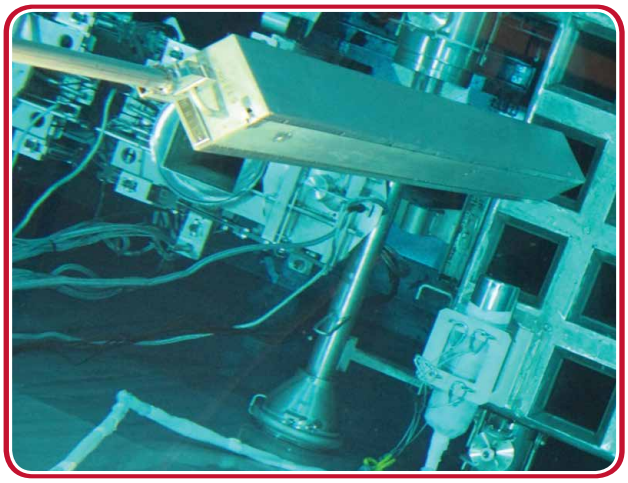
- Enhanced features over HLNC including:
  - Uniform axial response
  - Flat neutron energy response
  - Relatively insensitive to sample matrix effects
  - Large sample cavity
  - External neutron shielding
- High efficiency providing high counting rates and good precision
- High efficiency provides good sensitivity for milligram quantities of ^{240}Pu-effective

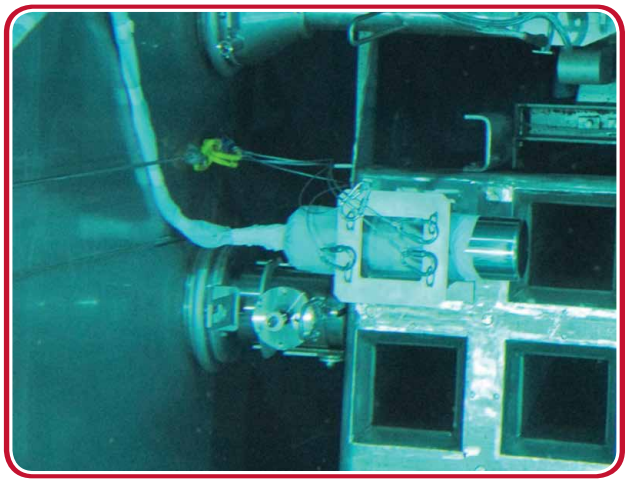
JCC-41

Special Safeguards Systems

As the world's leading supplier of NDA systems, CANBERRA offers a wide range of standard safeguards systems to address the requirements of many common nuclear surveillance issues. However, should the unique needs of a given application necessitate a custom solution, CANBERRA will partner with you to develop one.

CANBERRA's solutions are built from the company's core capabilities and competencies, including:





SMOPY: Spent Fuel Burn-Up Measurement Services

A NDA Service and Tool for Safeguards of LEU and MOX spent fuel assemblies.

An In situ nondestructive assay that:

- Enables time/cost saving and dose reduction
- Helps optimize the design of transportation casks and/or pond storage
- Simplifies the dialogue with Safety Authorities based on Burn-Up Credit confirmation
- Can be easily decontaminated (if necessary)
- Is small enough to fit onto a regular size car, to be transported from one site to another
- Capable of confirming burn-up measurement through two independent methods via dual gamma and neutron measurements and analyses
- Designed to measure a wide dynamic range: from very low irradiated fuels with long cooling time (typically 20 years) to high irradiated fuels with short cooling time (about 90 days)
- Capable of determining the Burn-Up of known or unknown fuel assembly
- Capable of distinguishing a MOX fuel assembly from a UOX fuel one with no prior knowledge of the assembly to be measured.

CANBERRA also provides Services to characterize and sort underwater waste using SMOPY system.

CEMO: **C**ontinuous **E**nrichment **MO**nitor

- Very highly stabilized NaI(TI) spectroscopy for passive and gamma transmission measurements
- Tamper proof installation
- 24/7 unattended instrument under seal

CEMO calls International Safeguards Community automatically if low enrichment is not confirmed

Under suitable conditions, the CEMO can measure enrichment to significantly better 0.1% accuracy and precision. It corrects for variations in gas density and pressure, count rate effects and detector temperature effects, peak width variations, and electronic drift.

CIND: Non Destructive Isotopic Monitor

- UF_6 monitoring in 48Y containers (natural or depleted U)
- Verifies that ^{235}U concentration in containers is less than 1%
- Combines a gamma passive measurement of ^{235}U (185 keV peak), with a correction factor for the container thickness
- No need for active neutron measurements

Unattended Monitoring

Unattended monitoring systems (UMS) permanently reside at nuclear facilities to generate safeguards data in between inspection visits. Such instruments are designed to operate autonomously, just relying on facility power but with sufficient battery backup to continue operation during outages. Data generated by UMS are generally protected both with software authentication and encryption algorithms and with anti-tampering protection measures. UMS are used throughout all fuel cycle facilities and perform a wide variety of safeguards measurements such as monitoring of fresh and spent fuel assemblies, characterizing MOX fuel and waste, measuring mass of special nuclear materials and determining vessel content characteristics. The future standard for UMS is a move towards fully integrated systems with local area networks using Ethernet connectivity and standard building blocks.

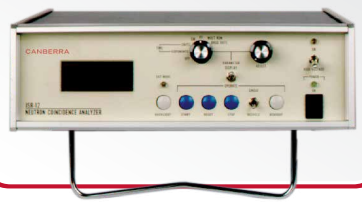
MiniGRAND: Miniature Gamma Ray and Neutron Detector

- Supports gross-pulse and current mode detectors and measurements as used in Safeguards monitoring and measurements
- Unattended and attended modes of operation possible
- Capable of functioning autonomously in the event of a power loss (resident battery operation) and/or communication outages (built in battery-backed-up storage)
- Built in self-diagnostic capabilities
- Front-panel emulator program provides an easy to use User Interface
- Compatible with all LANL unattended monitoring collect software
- May be configured as a standalone instrument or integrated into a board stack for use in detectors
- With the optional Mini-Instrument Family Application- Board Suite, the following capabilities can be supported:
  - Ethernet communications
  - Authentication of data files
  - Encryption of data files
  - Remote monitoring system

Shift Registers

- Neutron coincidence electronics used with all CANBERRA passive and active neutron counters
- Three models providing different capabilities – JSR-12, JSR-14, JSR-15
- Computer controlled setup of operational parameters
- LCD display for menu-driven operator setup of count time, pre-delay, gate width and high voltage (JSR-12, JSR-15)
- 4 MHz clock (JSR-12, JSR-14)
- Battery powered, portable unit for operation in totals, coincidence, and multiplicity mode (JSR-14, JSR-15)
- 50 MHz clock (JSR-15) for high count-rate applications
- Nonvolatile storage of setup parameters and run data for up to 3000 data runs
- Buffer status command to insure no loss of data on long runs
- Count gate output for control of external acquisition electronics

JSR-12



JSR-14

JSR-15

PIMS

- Plutonium Input Counter
- PuO2 Canister Verification System
- Designed for simultaneous passive neutron coincidence counting and gamma isotopics
- Designed to verify the plutonium content in up to 5 cans inside stainless steel canister
- Flat axial counting response over the height of the canister
- Telescope Ge detector – 12% coax and LEGe detectors in a single cryostat
- Integral load cell platform for weight verification
- Mass range from 4.5 to 18 kg Pu

PIMS

Containment and Surveillance

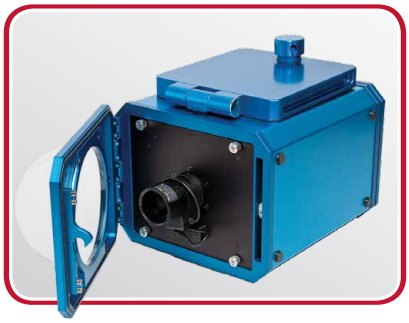
Containment and surveillance (C/S) techniques, based mainly on optical surveillance and sealing systems, are applied to supplement nuclear material accountancy by controlling access to nuclear material and detecting any undeclared movement of the material. Safeguards agencies use C/S techniques extensively because they decrease inspection costs and reduce disruption of normal operations of nuclear facilities.

Surveillance Equipment

DCM-C5 Camera - NGSS

- Color surveillance camera
- Picture Taking Interval: up to one picture per second
- Optional fish eye lens for 180 degrees view
- C-mount lens, DC Auto-Iris connector
- 5 Megapixel CMOS color image sensor
- 600 MHz digital signal processor (DSP)
- 64 MB SD-RAM, 4 MB Flash
- SD memory card for data storage with FAT32 file system
- Li-Ion rechargeable battery (optional)
- 10/100 MB Ethernet
- High-speed RS-485 and Low-power RS-485
- USB port
- 5.5 inch TFT monitor for optional menu-driven operator interface

- Four isolated digital inputs, one non-isolated digital input, four isolated digital outputs
- Tamper indicating enclosure with magnetic housing switch
- Secure storage for cryptographic keys
- Flexible triggers
- Electronic pan-tilt-zoom (EPTZ) support
- MPEG-2 video codec and JPEG images
- TCP/IP communications



Legacy Surveillance Equipment

CANBERRA has supplied safeguards agencies around the world with surveillance equipment for many years. As technology has improved, CANBERRA has updated its equipment and revised its offer to these agencies. The below equipment is widely in use by international agencies but does not represent our current offer. Please contact the factory for further information.

ALIS: All In One System

ALIP: All In One Portable Camera System

DSOS: Digital Single Channel Optical Surveillance System

SDIS: Server Digital Imaging System

→ Containment (Seals)

EOSS

- Replaces the VACOSS
- Logs tamper events, open/close events, inspection data, and seal status
- Portable, active reusable seal
- Tamper proof enclosure
- Encrypted data storage

RMSA: Remotely Monitored Sealing Array

- Portable, active and reusable sealing system
- Monitors and records tamper events, inspection data and seal status
- Provides requested or periodic State of Health updates
- Provides intrinsic tamper indication
- No external power required, battery operated
- 4+ years surveillance between battery replacement
- Secures Seal data with encryption and authentication techniques
- Communicates all relevant data to a data Translator station via RF communication link
- Uses license free frequency band applicable in USA and Europe
- Many seals (hundreds) can be linked to a single translator station
- Allows remote transmission of Seals and Seals events for off-site review

Overview of the RMSA system:

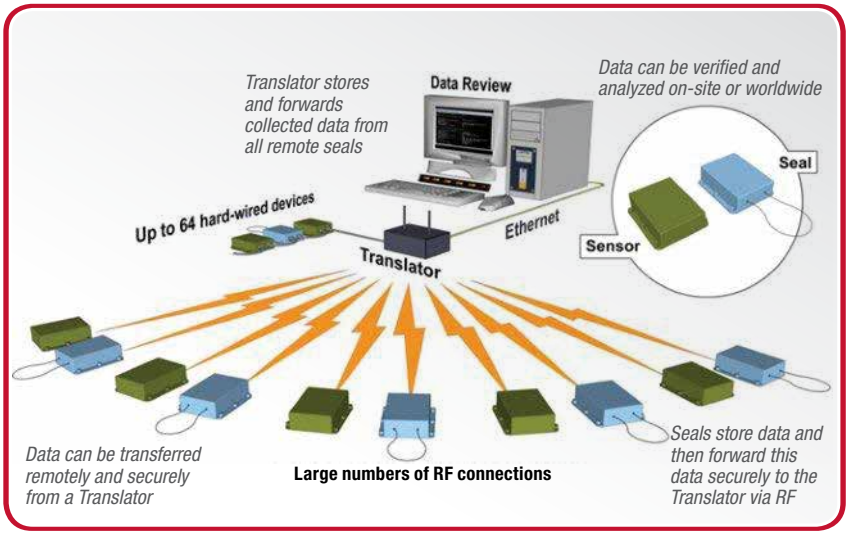


Image courtesy of Sandia National Laboratories

CANBERRA

CANBERRA has been serving the nuclear community for over five decades.

The company is the leading provider of innovative and cost-effective nuclear measurement solutions used to maintain safety, assess the health of nuclear facilities and safeguard the public and the environment. Since 1968, CANBERRA has also been committed to the development, manufacturing and service of unique specialty detectors for international scientific experiments and specialty designs.

Driven by diverse needs in fundamental and applied research applications, a range of technologies has been developed over many years that enables CANBERRA to maintain its technological leadership in semiconductor detector development.

CANBERRA has been supplying detectors and instrumentation used in cutting-edge materials analysis, physics, and space studies to some of the world's leading industries and research institutes. CANBERRA's dedicated R&D structure allows us to deliver innovative nuclear detection systems based on a comprehensive exploration of all available and emerging technologies.

Our passion for fully understanding the needs of our customers is key to our ability to provide the best solutions to contribute to their success.

Total Quality Control

It is our policy that:

All products and services we offer will meet or exceed the specified requirements and anticipated expectations of our customers. This policy is supported at all levels within the organization.

Our approach to quality is modelled after the concept of Total Quality Control. This approach places the responsibility for quality of work on each employee. All employees are empowered to stop work or processes if they believe quality is in question, and they are encouraged to report quality issues immediately to management. The goal of this approach is 100% Customer Satisfaction. By focusing on our chosen marketplace, continuously improving our products and processes, and constantly innovating, we believe we create the greatest value for our customers.

- CANBERRA detectors are particularly environment friendly. They are designed according to ECO design rules.
- CANBERRA detector manufacturing is therefore in conformity with the RoHS or REACH norms as well as OSHAS18001 certification.
- Systems are designed to comply with European Directives (EC).
- CANBERRA's quality system meets ISO 9001 standards, and the company holds appropriate certifications in all countries and regions in which we operate. Certificates can be obtained by contacting your local sales or service office.

ISO 9001 SYSTEM CERTIFIED

CANBERRA SERVICES
1-800-255-6370

CANBERRA SERVICES
α β γ n

CANBERRA Services augments your technical team, assists during peak periods, provides expert advice, trains staff and maintains your systems for optimal performance. We look forward to partnering with you.

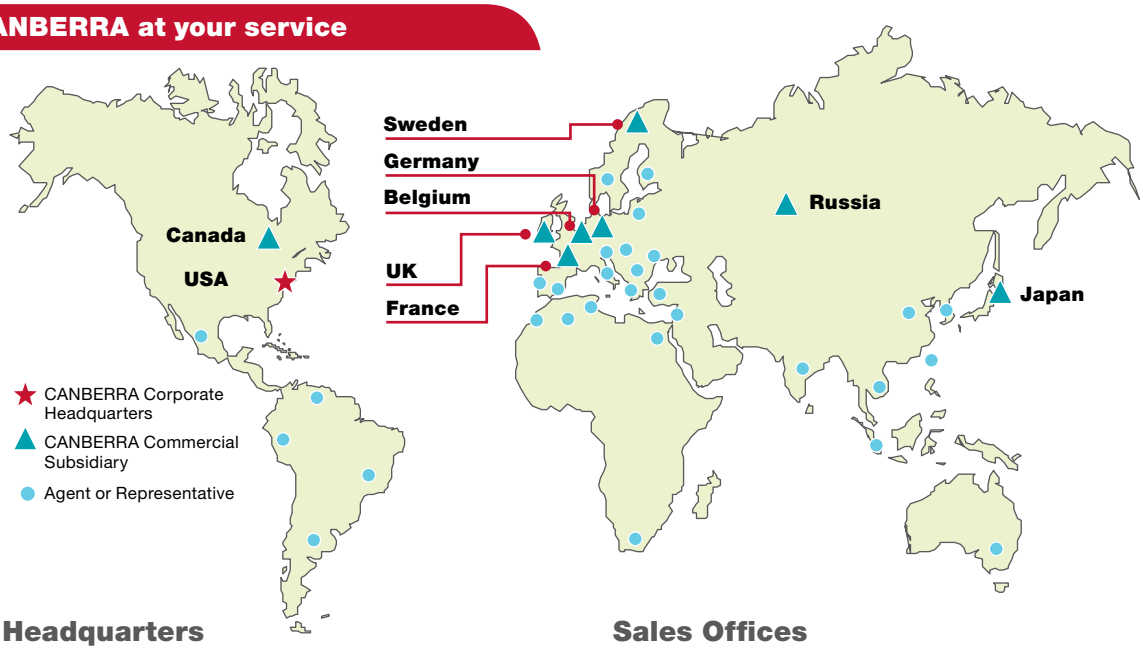
Who we are, where to find us

CANBERRA has been serving the nuclear community for over five decades. The company is the leading provider of innovative and cost-effective nuclear measurement solutions used to maintain safety of personnel, assess the health of nuclear facilities and safeguard the public and the environment.

CANBERRA operates production and engineering facilities worldwide. Our 1000+ employees are all focused on bringing the very best nuclear technology to your operation.

We strive to be recognized by our customers for consistently exceeding their expectations.

CANBERRA at your service



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International Offices

- Please visit CANBERRA's web site at **www.canberra.com** and click on "Offices" for a complete listing.

Sales Offices

- CANBERRA sales and service capability exists in virtually every country in the world.

CANBERRA

ISO 9001
SYSTEM
CERTIFIED

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