



GAMMA WASTE ASSAY SYSTEMS

SGS™

*Standard Segmented
Gamma Scanner*



FEATURES

- Quantitative gamma analysis for fission products or TRU (alpha) radionuclides
- Segment by segment assay results
- Compact design for reduced footprint
- NDA-2000™ software provides setup, calibration, and QA capabilities
- Fully integrated PLC-based electromechanical control system
- CE compliant
- Optional automatic weighing system

CUSTOMER BENEFITS

- Reduced integration and Installation time on-site
- Ease of maintenance
- Transportability within site

APPLICATIONS

- Nuclear Waste Assay
- Decontamination and Decommissioning (D&D)
- Nuclear safeguards
- Research laboratories

INTRODUCTION

The Mirion Standard Segmented Gamma Scanner (SGS system) is designed to perform accurate quantitative assays on gamma emitting nuclides found in fission products, activation products, and Transuranic (TRU) waste. With the optional ASTM algorithms it is also designed for use in safeguards applications. The system provides very accurate assays through the use of a collimated high purity germanium detector. The container is divided into a number of vertical segments and the activity is quantified in each vertical segment using matrix correction techniques based on attenuation corrections.

The system is designed to assay drums with volumes up to 200 L (55 gal) and weights up to 454 kg (1000 lb). The total system footprint is less than 4 m² (<36 square-feet) with a maximum height of 213.4 cm (84 in.) including lightpost; 157.5 cm (62 in.) to the top of the frame. Forklift pockets provide for easy transport within a facility.

The system is designed to assay radionuclides such as ⁶⁰Co or ¹³⁷Cs with drum activities ranging from approximately 100 nCi up to approximately 20 mCi. For transuranic waste the system is optimized for assaying drums containing 0.1 grams ²³⁵U or 0.2 grams ²³⁹Pu up to 1000 grams. There is some flexibility in the detector size and collimation that can be used to modify the dynamic range of the system.

The following sections describe the system hardware and software as well as the typical system performance.

DESCRIPTION

The Standard SGS system consists of a main frame that comprises a Base, Turntable, and Elevator assembly, and a separate Mechanism Enclosure (not pictured) required for the electrical controls. The Detector and Transmission assemblies are situated on a platform that moves vertically with the elevator. Control of the full system as well as analysis of the assay results are achieved using the Mirion NDA-2000 software running on a standard PC.

PERFORMANCE

While system performance will depend on the actual measurement conditions, under the following conditions the standard WM2200 waste assay system has an MDA of approximately 0.1 µCi for ¹³⁷Cs or 0.2 g for ²³⁹Pu:

- Standard 200 L (55 gal) drum
- Density less than 0.3 g/cc
- Background less than 0.02 mR/hr
- No other significant nuclides present
- 30 minute assay time

This sensitivity can be modified by detector size, assay time, and geometry. The typical dynamic range is five to six orders of magnitude. The accuracy of the measurement is based on the uniformity of the activity distribution and the density and homogeneity of the waste material. Typical accuracies are within ±20% for 0.3 g/cc density drums. Accuracies can vary with increased drum density and non-homogeneity.

BASE, TURNTABLE, AND ELEVATOR ASSEMBLY

The Base, Turntable and Elevator assembly for the Standard SGS system are integrated into a main frame that provides the overall support for the system. The system has a compact design that minimizes floor space and will fit through a standard double-wide door. Adjustable levelers provide a means to level and stabilize the system, and fork lift pockets are built in for mobility.

The turntable rotator assembly is designed to accommodate both 100 L (30 gallon) and 200 L (55 gallon) drums with a maximum weight capacity of 454 kg (1000 lb). The rotation speed is set to 4-6 RPM at the factory. Loading and unloading of drums must be handled using a drum loader or loading ramp; automated drum loading via a conveyor system is not available with this system. A weigh scale is an available option to the turntable assembly. The expected accuracy of the weighing system is ±3 kg (6.6 lb) over the full range and the scale result can be automatically exported to the assay software through the PLC system.

Note that the measurement result depends on a drum weight (used in the multi-curve density calibration). If the drum weight is available through other means from the facility operation, it can be entered at the start of the assay by an operator.

The elevator assembly provides accurate and repeatable vertical positioning of the detector and transmission source which allowing for the segmented scanning of the drum. A stepper motor drives the vertical lift with the rate and amount of travel communicated by NDA-2000 software to the PLC. The vertical range of the lift is 91.4 cm ±3 mm (~36 in.).

DETECTOR ASSEMBLY

A high purity germanium detector is used for detection of the gamma emitting nuclides from the drums. The detector provided with the standard system is a 30% relative efficiency coaxial detector with a resolution better than 2.0 keV at 1332 keV. Alternative detector choices are available as options including broad-energy BEGe™ detectors. The limitation on the detector size is determined by the detector endcap diameter of 3.5 in.

The detector is contained in a collimator fixture that is mounted on a platform on one side of the elevator assembly. The collimator fixture defines a collimated view of the drum segments and shields the detector from unwanted background radiation. The detector shield is a cylindrical steel weldment filled with poured lead and has the following dimensions:

- Detector collimator opening: 101.6 mm (4 in.)
- Depth: 158.8 mm (6.25 in.)
- Lead shielding thickness: 54.1 mm (2.13 in.)

The collimator portion of the fixture is a rectangular steel weldment with poured lead for shielding and has the following dimensions:

- Fixed opening: 101.6 mm (4 in.) high by 254 mm (10 in.) wide by 203.2 mm (8 in.) deep
- Lead shielding thickness: 54.1 mm (2.13 in.)

Table 1. MDAs for selected nuclides under standard measurement scenarios.*

| Nuclide | Daughter | Energy (MeV) | LLD (µCi) | LLD (kBq) | LLD (g) |
|-------------------|--------------------|--------------|-----------|-----------|---------|
| ¹³⁷ Cs | ¹³⁷ Ba | 0.662 | 0.1 | 3.7 | |
| ¹³⁴ Cs | | 0.796 | 0.1 | 3.7 | |
| ⁶⁰ Co | | 1.173 | 0.1 | 3.7 | |
| ¹⁵² Eu | | 1.408 | 0.4 | 14.8 | |
| ²³⁵ U | | 0.185 | 0.2 | 7.4 | 0.1 |
| ²³⁸ U | ^{234m} Pa | 1.001 | 20.0 | 740.0 | 59.0 |
| ²³⁹ Pu | | 0.414 | 12,000 | 4.4E5 | 0.2 |

*Standard 200 L (55 gal) drum. – Density less than 0.3 g/cc. – Background less than 200 nGy/hr (20 microRad/hr). – No other significant nuclides present. – 30 minute assay time. – Standard GC3020 detector.

The inner surfaces of the detector shield and the opening of the collimator are lined with 1.6 mm (.06 in.) thick copper over 1.6 mm (.06 in.) thick tin.

The Standard SGS system supports two detector cryostat configurations; the standard 7905SL-15 and the optional Cryo-Pulse® 5 unit. The 7905SL-15 is a 15 liter LN₂ horizontal integral Slimline™ cryostat configuration. The Cryo-Pulse 5 option provides continuous electrical cooling with no need for LN₂. The cryostat is mounted to a sliding plate assembly and detector mount slides to allow for some flexibility in the position of the detector relative to the drum.

TRANSMISSION SOURCE SHIELD ASSEMBLY

The transmission source shield fixture is mounted on the opposite side of the detector collimator fixture on the same elevator assembly platform. (The two fixtures are interchangeable if so desired.)

The transmission fixture houses the transmission source in a lead shield and provides 101.6 mm (4 in.) of lead shielding completely around the source. The transmission beam is exposed by the automated opening of a tungsten shutter plug mounted to a slider assembly. For fail-safe operation (power removed), the tungsten shutter plug drops to block the transmission source beam path. The transmission source shield and shutter is designed to shield a transmission source with activities up to 370 MBq (10 mCi) to minimize worker radiation exposures. The shielding reduces the measured surface dose rate to 12 micro Gy (1.2 mRad).

The standard transmission source is ¹⁵²Eu, but other options are available if desired. Alternate choices must be evaluated with a Mirion technical expert during the quote process. For instances where shipping restrictions preclude delivery of sources, alternate arrangements can be made following an evaluation with a Mirion technical expert.

MECHANISM ELECTRICAL CONTROL ENCLOSURE

The Mechanism Electrical Control Enclosure houses the PLC and all of the associated electrical protection and control devices required to perform commands and monitor the SGS mechanism. The heart of the mechanism electrical control is the GE/FANUC

Series 90/30 model 313 PLC. The PLC interfaces to the application software on the computer through the COM1 RS-232 serial port of the computer via a RS-232 to RS-422 adapter. (The PLC uses RS-422 communication.) With appropriate adapters, the interface to the computer can be modified to either full RS-422 or USB (consult factory).

NUCLEAR COUNTING ELECTRONICS / COMPUTER

The Nuclear Counting Electronics consist of the Mirion DSA-1000™ multi-channel analyzer (MCA) and a reference pulser. The DSA-1000 unit or (optional) Lynx® Digital Signal Analyzer (DSA) and a reference pulser. These DSAs provide the high voltage required by the detector and perform the data collection. The MCA also reads the HV inhibit by monitoring the thermistor within the detector assembly. The pulser is used to provide a stable reference peak for the spectrum for gain stabilization and/or live time correction. The computer serves as the primary controller of the system and all sub-systems. Genie™ 2000 and NDA-2000 software are the application software packages used to control the system. Refer to the software user and technical reference manuals for information on these packages.

WASTE ASSAY APPLICATION SOFTWARE

The Mirion Genie 2000 based NDA-2000 Non-Destructive Assay Software is used as the application software. The software is designed to run under Windows XP (certified for Windows 7 32-bit) and utilizes all of the standard Genie 2000 high resolution gamma spectroscopy techniques. In addition, some of the features included in the software are:

- A high level menu structure for ease of use
- Multiple matrix correction techniques including:
 - Average Density
 - Differential peak analysis
 - Transmission Correction
- Extensive QA and measurement control routines
- Automated calibration routines
- Archiving capabilities
- User editable report templates
- Compliant with NQA2 and ISO9001

A more detailed description of the application software can be found in the NDA-2000 specification sheet.

RELATED SYSTEMS

- Modular Segmented Gamma Scanner – Similar to the Standard SGS system but with a modular design that permits the system to be optimized for customer’s measurement application. Can accommodate up to 320 L (85 gal) drums with weights up to 900 kg (2000 lb) in its standard configuration.
- Segmented Can Scanner – Segmented Gamma Assay System SGS assay system optimized for waste and scrap materials in containers less than 30 cm in diameter.
- SGS High Activity – SGS assay of Intermediate Level Wastes in 200 liter and larger drums with surface exposure rates in excess of 100 R/hr.
- SGS High Throughput – SGS assay of drums using multiple HPGe detectors for increased throughput.
- SGS Shielded Multi-Detector – Segmented Gamma Analysis system using multiple HPGe detectors and a 4π low background steel shield provides both the accuracy of the SGS analysis and low detection levels.
- TGS™ Tomographic Gamma Scanner – Provides improved accuracy over the standard SGS system along with images of the drum contents.

ORDER RELATED INFORMATION

The Standard SGS system includes:

- One compact integrated structure with PLC Control System
- GC3020 detector in 7905SL-15 cryostat
- Shielded detector housing
- Shielded shutter assembly for transmission source
- Typical gamma source: ¹⁵²Eu, 10 mCi (can be supplied locally)
- DSA-1000 electronics
- Genie 2000 and NDA-2000 software
- Calibration (based on 200 L-drum measurements)
- Documentation including installation procedure, operational procedure, and calibration report, provided on CD-ROM

OPTIONAL ITEMS INCLUDE:

- ISOCS™ detector calibration and software
- BEGe detector (maximum endcap size must be determined)
- CP-5 cryostat for LN₂-free solution
- Lynx Digital Spectrum Analyzer
- MGA™/FRAM™/IGA software for U/Pu measurements
- Drum weighing system (up to 450 kg)
- Factory Acceptance Test, Site Acceptance Test, Training
- Optional transmission sources
- Request a quote to see other options

Table 2. Physical Specifications

| FOOTPRINT | |
|-----------------------------|-----------------------------------------------------------------------|
| Mechanism | 262 cm (103 in.) wide x 127 cm (50 in.) deep x 213.4 cm (84 in.) high |
| Mechanism Control Enclosure | 84 cm (32.9 in.) wide x 66 cm (25.9 in.) deep x 91.4 cm (36 in.) high |
| POWER REQUIREMENTS | |
| Counting Electronics | 15 A at 220 V |
| Mechanical System | 10 A at 220 V |

