



# WM2200

## Series Segmented Assay System



### KEY FEATURES

- Complete quantitative gamma analysis for fission products or TRU (alpha) radionuclides
- Modular design permits system to be optimized for customer's measurement application
- Large coaxial or Broad Energy Detector for optimal performance
- NDA-2000™ Non-Destructive Assay Software provides extensive setup analysis, calibration, and QA capabilities
- MGA™/MGAU™ U-Pu isotopics software
- Fully compatible with ISOCS™ methodology and calibrations
- PLC-based electromechanical control system
- Many optional capabilities available including:
  - Automatic weighing system
  - Surface dose rate measurement
  - Inline automated conveyor system

### INTRODUCTION

The Mirion WM2200 Segmented Assay System is designed to perform accurate quantitative assays on gamma emitting nuclides found in fission product, activation product, 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 which calculate the average matrix density for each segment.

The standard system configuration is designed to assay 200 liter (55-gallon) drums and support weights up to 900 kg (2000 lb). Optional configurations have been provided for larger or heavier containers from 320 L (85 gal) drums to HICs.

The standard system is designed to assay radionuclides such as  $^{60}\text{Co}$  or  $^{137}\text{Cs}$  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 gram up to 1000 grams of  $^{235}\text{U}$  or  $^{239}\text{Pu}$ . Detector size and collimation 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 waste assay system utilizes the Mirion modular mechanism design. This design provides the flexibility to easily add features such as transmission correction or to upgrade from a manual to an automatic system. This design can also be adapted for a variety of container sizes and weights.

## MODEL 2442 MECHANISM

The mechanism is a modular design and consists of one or more of the following modules: 2442 detector vertical drive module, 2442R-24 turntable rotation module or optional inline conveyor rotator, 2442T transmission vertical drive module, 2442S single transmission source shield and shutter.

The 2442 detector vertical drive unit is a stepper motor driven vertical drive platform which will raise and lower the germanium detector, collimator, and optional dose measurement system over a vertical range of 114 cm (45 in.). The unit is designed to handle operational weights up to 680 kg (1500 lb). This permits use of large collimators if necessary when measuring high activity containers. A variety of collimators and detector shields are available. The drive is designed for use with any of the following detector cryostats: horizontal integral, cryoelectric, or 7935-7 Big MAC cryostats.

The 2442R is the manual turntable module. This module can be equipped with a variety of turntable sizes depending on the measurement requirements. The turntable module is designed to handle a maximum diameter of 76 cm (30 in.) and weight of 900 kg (2000 lb). The turntable uses a dc motor which can be set up to rotate at speeds from 1 to 10 rpm.

The inline conveyor/rotator is an optional drum rotator module which can be used to automatically load, assay, and unload drums from infeed and outfeed conveyors.

An optional digital scale can be interfaced into the PLC system to automatically weigh the drum and enter this weight into the application software during the assay. The accuracy of the weighing system is  $\pm 4$  kg (8.8 lb).

## TRANSMISSION CORRECTION (OPTIONAL)

The transmission correction module consists of the transmission source shield and safety shutter, and travels on the transmission vertical drive in synchronization with the detector vertical drive. If not used, the density is obtained from the weight of the container, but all other aspects of the segmented measurement are unchanged.

The transmission module houses the transmission source in a lead shield and provides approximately 101.6 mm (4 in.) of lead shielding completely around the source to minimize worker radiation exposures. 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 are designed to shield a transmission source with activities up to 555 MBq (15 mCi). The shielding reduces the measured surface dose rate to no more than 12 microGray per hour (1.2 mRad per hour). The quoted value corresponds to the side surface of the shield (i.e. on contact) at the point closest to the source inside the shield. The dose rates at other locations around the shield are substantially lower.

## MODEL 2445 CONTROL SYSTEM

The Model 2445 control system is a PLC-based controller with associated contactors, stepper motor controllers, I/O modules, drivers, etc. The PLC utilized is GE RX3i. The PLC interfaces to the application software through an RS-485 interface. The flexibility of this design permits it to be easily modified to interface to a customer's process line. The control system is mounted in a locking NEMA 12 enclosure to ensure security, safety, and environmental control.

A touch screen control panel is provided with the system to allow local or remote control of the mechanism. The panel provides a convenient interface for control of the mechanism during testing or maintenance.

## DETECTOR AND ELECTRONICS

A high purity germanium detector is used for detection of the gamma emitting nuclides from the drums. The detector provided with the standard WM2200 system is a 30% relative efficiency "P" type coaxial detector with a resolution of 1.9 keV at 1332 keV. The detector is housed in a horizontal integral cryostat. As an option, an electrically cooled detector based on the Mirion Cryo-Pulse® cooling technology can be provided. Other detector sizes can be specified to improve low level sensitivity or to improve the high activity performance.

The counting electronics utilize a Mirion integrated Multichannel Analyzer based on advanced digital signal processing (DSP) techniques.

## WASTE ASSAY APPLICATION SOFTWARE

The Mirion Genie™ 2000 based NDA-2000 Non-Destructive Assay Software is used for WM2200 applications. The application software is designed to run on the Windows platform 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.
- Full data review and reanalysis capability.
- Integrates measured plutonium isotopics (MGA analysis).
- Total Measurement Uncertainty (TMU) Analysis.
- Extensive QA and measurement control routines.
- Automatic calibration selection for each measurement geometry.
- Archiving capabilities.
- Customizable report templates.
- Compliant with NQA-1 and ISO9001.
- Can be customized to interface with facility databases (e.g. LIMS).

A more detailed description is included in the NDA-2000 spec sheet.

## PERFORMANCE

System performance will depend on actual measurement conditions. Under the following conditions the standard WM2200 waste assay system has an MDA of approximately 0.1  $\mu\text{Ci}$  for  $^{137}\text{Cs}$  or 0.2 gm for  $^{239}\text{Pu}$ :

- Standard 200 L (55 gal) drum.
- Density less than 0.3 gm/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  $\pm 20\%$  with maximum errors being in the range of 50% for drums with densities up to 1 gm/cc.

## RELATED SYSTEMS

- **SGS™ Segmented Can Scanner** – Optimized for small containers (<30 cm in diameter) containing waste and scrap materials.
- **SGS High Activity** – Assay of Intermediate Level Wastes in 200 liter and larger drums with surface exposure rates in excess of 100 R/hr. Includes additional attenuators and detector retraction mechanism that adjusts automatically for high count rate samples.
- **SGS High Throughput** – Assay of drums using multiple HPGe detectors combined with automatic loading and unloading for increased throughput.

Table 1. SGS Detection Levels using a GC3020 coaxial detector – 30 minute total assay (includes movement), for a low-density drum with a uniform source distribution.

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

Table 2. Physical Specifications

| MODULE WEIGHTS (approximate)      |                                  |
|-----------------------------------|----------------------------------|
| Detector Drive Module             | 550 kg (1200 lb)                 |
| Detector and Drive Collimator Add | 365 kg (800 lb)                  |
| Rotator Module                    | 160 kg (350 lb)                  |
| Conveyor/Rotator Module           | 230 kg (500 lb)                  |
| Transmission Drive Module         | 230 kg (500 lb)                  |
| FOOTPRINT                         |                                  |
| Detector Drive Module             | 81 cm (32 in.) x 137 cm (54 in.) |
| Rotator Module                    | 81 cm (32 in.) x 81 cm (32 in.)  |
| Transmission Drive Module         | 81 cm (32 in.) x 81 cm (32 in.)  |
| POWER REQUIREMENTS                |                                  |
| Counting Electronics              | 15 A at 110 V                    |
| Mechanical System                 |                                  |
| Manual                            | 30 A at 110 V                    |
| Automated                         | 60 A at 110 V                    |

The system size, weights, and power requirements, depend on the system configuration. The parameters presented here are for approximate planing purposes.

- **SGS Shielded Multi-Detector** – Segmented Gamma Analysis system using multiple HPGe detectors and a  $4\pi$  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. See TGS specification sheet for details.



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