



# WM2900

## TGS™ Tomographic Gamma Scanner



### KEY FEATURES

- Complete quantitative gamma analysis for fission/activation 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
- Los Alamos NIS-6 based tomographic analysis algorithms
- MGA™/MGAU™ U-Pu isotopics software
- Fully integrated software
- Full spectral acquisition and storage at each grab
- Storage of all 32k spectral data from each grab (position correlated measurement)
- Region of Interest based gamma-line analysis
- Storage of all acquisition parameters
- Full re-analysis capability
- Ability to alter Regions of Interest, Calibrations, and more for Post Acquisition Analysis
- Automated emission and transmission image reconstruction
- Interactive Graphics Package
- PLC-based electromechanical control system
- Many optional capabilities available including:
  - Automatic weighing system
  - Surface dose rate measurement
  - In-line automated conveyor system

### INTRODUCTION

The WM2900 TGS is the Mirion Tomographic Gamma-ray scanning system for Safeguards and Waste Assay applications. The system is designed to accurately quantify plutonium, uranium, fission and activation products in a variety of containers from 20 L pails to 200 L drums in overpacks.

The TGS system uses high purity germanium detection and low spatial resolution transmission and emission imaging to obtain improved measurement accuracy over non-imaging gamma-ray techniques. The container is analyzed in a three-dimensional grid of discrete volume elements called voxels. The activity is quantified in each of these voxels using matrix correction techniques based on the activity content and matrix properties of each voxel.

Data is acquired by scanning hardware with high resolution HPGe detector electronics. Matrix mapping is performed by applying Beers Law to rays from the center of each voxel to the center of the detector face. Special image reconstruction software is used to allow for the response of the collimator in combination with the properties of the waste. A comprehensive graphics package allows the attenuation map and emission image to be visualized from different perspectives.

The system is designed to assay drums with volumes up to 340 L and weights up to 1000 kg (2200 lb) in its standard configuration. Optional configurations can be provided for larger or heavier containers. A detector horizontal drive option is also available to allow assay of smaller containers (e.g. 20 L pails).

The standard system is designed to assay radionuclides such as  $^{60}\text{Co}$  or  $^{137}\text{Cs}$  with drum activities ranging from approximately 500 nCi up to approximately 100 mCi. For transuranic waste the system is optimized for assaying drums containing 0.4 g up to 1000 g 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 an upgrade from a manual-load to an automatic-load system. This design can also be adapted for a variety of container sizes and weights.

### TGS MECHANISM

The mechanism is a modular design and consists of one or more of the following modules: 2442 detector vertical drive module, 2942R-27 turntable rotation module or optional in-line conveyor rotator, 2442T transmission vertical drive module, and 2942S single transmission source shield and shutter. These are described in detail below.

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 1100 mm (43.5 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 2942R is the manual-load 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 686 mm (27 in.) and weight of 1000 kg (2200 lb). The turntable module is mounted on a motorized track to provide the translational movement required for the tomographic imaging analysis. The rotator platter can be easily replaced to accommodate larger items.

The in-line 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 transmit this weight into the application software during the assay. The accuracy of the weighing system is  $\pm 4$  kg (8.8 lb) at full scale.

### TRANSMISSION CORRECTION

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. 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.

### MECHANISM CONTROL SYSTEM

The mechanism 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.

Module Weights (approximate)	
Detector Vertical Drive, Detector and Collimator	998 kg (2200 lb)
Rotator Module	590 kg (1300 lb)
Transmission Drive Module and Shield	335 kg (734 lb)
System Foot Print	
Width	2920 mm (115 in.)
Depth	1830 mm (72 in.)
Height	2670 mm (105 in.)
Power Requirements	
Counting Electronics	15 A at 110 V
Mechanical System	60 Hz, 220 V ac, 20 A

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

### 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 WM2900 system typically has a relative efficiency of 45% or higher, and a resolution of 2.0 keV at 1332 keV. (A resolution at low energies of <0.75 keV at 122 keV, can be specified for the use of MGA and MGAU software in measuring plutonium and uranium.) The detector is housed in a horizontal integral cryostat. As an option, an electrically cooled detector based on the Mirion Cryo-Pulse<sup>®</sup> 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.

## VISUAL REPRESENTATION

The primary purpose of the tomographic analysis is improved accuracy while the images are generated to facilitate data review. NDA 2000 software is provided with a number of powerful imaging tools. The images can be displayed interactively and in a variety of modes. Vertical and horizontal slices for both transmission and emission measurements (Figures 1 and 2) provide information on source positioning and matrix uniformity. 3-D projections (Figure 3) and continuous rotation modes are provided to allow easier visualization of relative source positions.

The NDA 2000 TGS analysis will also generate a series of vertical drum slices in the TGS Viewer.

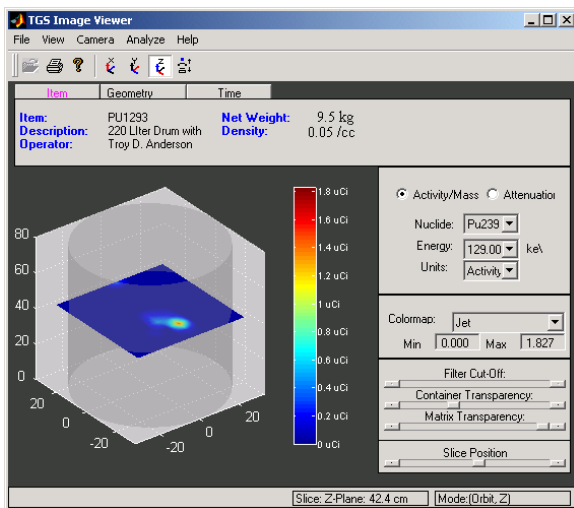


Figure 1.

Typical TGS vertical slice showing a hot spot near the center of the drum.

## PERFORMANCE

System performance will depend on actual measurement conditions. Under the following conditions the standard WM2900 waste assay system has an MDA of approximately 0.2  $\mu$ Ci for  $^{137}\text{Cs}$  or 0.4 g for  $^{239}\text{Pu}$ :

- 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.
- 60 minute total assay time.

This sensitivity can be modified over a wide range by detector size, assay time, and geometry – both distance and collimator. The typical dynamic range is five to six orders of magnitude. The accuracy of the measurement depends on the uniformity of the activity distribution and the density and homogeneity of the waste material.

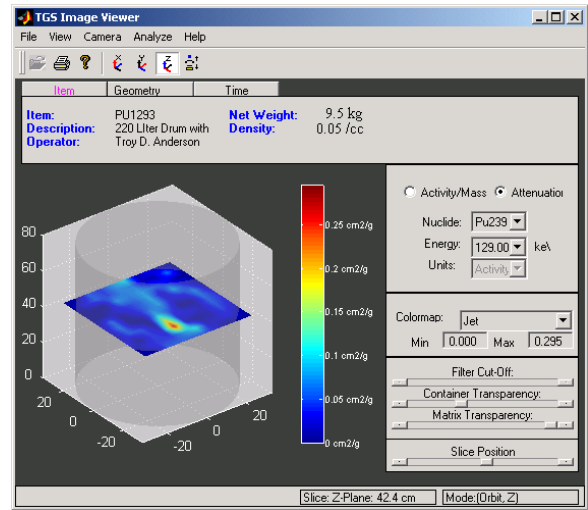


Figure 2.

Typical TGS vertical slice showing a high density object at the same location as the hot spot shown in the Figure 1.

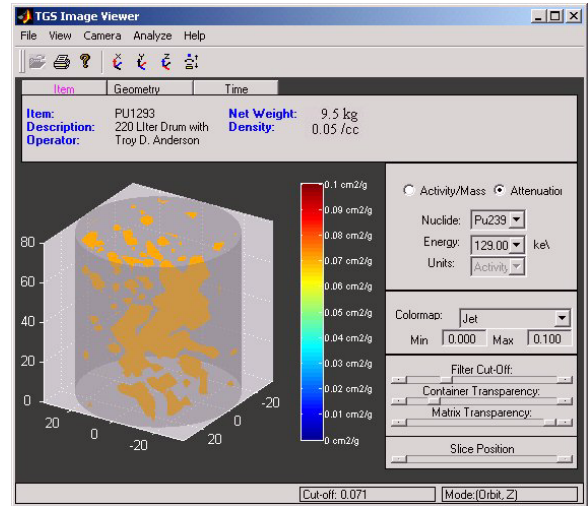


Figure 3.

3-D projection from the transmission measurement. The high density portions of the drum matrix are displayed in this screen.

## SPATIAL RESOLUTION

For a typical 200 L drum analysis, a grid of 10 x 10 horizontal and 16 vertical segments are used to provide a voxel size of 56 mm (2.2 in.). The number of horizontal and vertical divisions can be varied by the user to provide improved resolution or decreased assay time.

Typical accuracies obtained are  $\pm 10\%$  for 200 L drums with densities up to 1 g/cc. Both non-self attenuating sources in heterogeneous waste forms and non-uniform activity distributions can be measured accurately.

## WASTE ASSAY APPLICATION SOFTWARE

The Mirion Genie™ 2000 based NDA 2000 Non-Destructive Assay Software is used for WM2900 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. NDA 2000 software seamlessly combines assay results from complimentary assay techniques when a suite of equipment is demanded.

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.
- Tomographic imaging and analysis.
- 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 ISO 9001.

A more detailed description is included in the NDA 2000 (S529C) specification sheet.



A variety of collimating apertures are available to provide the desired resolution and sensitivity.

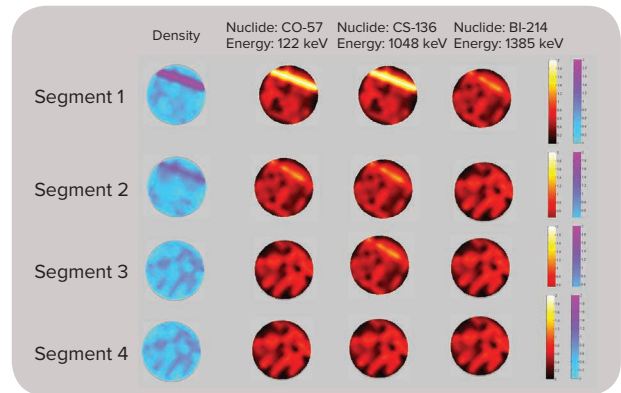


Figure 4.  
Partial TGS summary printout showing a summary of the transmission and emission images.



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