Passive Neutron and Gamma Drum Monitor

B2307-220

Introduction

The ANTECH Model B2307-220 Passive Neutron and Gamma Drum Monitor is an integrated system based on combining the N2221-220 Passive Neutron Drum Monitor with a Plutonium/Uranium isotopic gamma scanning instrument such as the ANTECH G3500 series.

It is a comprehensive measurement system for the determination of plutonium mass in intermediate (ILW), transuranic (TRU) or low level waste (LLW) using passive neutron coincidence or multiplicity counting and incorporating a gamma scanner for determining plutonium and uranium isotopic ratios. It provides a total plutonium mass measurement in one integrated system and it can also be used to measure mixed oxide (MOX) fuel waste, which includes both plutonium and uranium. The gamma ray isotopic analysis is performed by the PC/FRAM, MGA or another isotopic analysis code.

User-friendly Windows software controls the semi-automatic loading of 220 litre (55 gallon) drums and the gamma ray and neutron data acquisition and analysis algorithms. The neutron instrument determines the Pu-240 effective mass ($^{240}Pu_{effective}$) and the high purity germanium (HPGe) gamma ray scanning instrument determines the Pu (and U) isotopic ratio data. This data is combined to determine the mass of all of the individual plutonium (and uranium) isotopes.

As with the Model N2221-220, the neutron detection system is based on 16 rectangular polyethylene modules. Each of these modules contains four ^{3}He tubes that are connected to a high voltage junction box. Each junction box contains an Amptek A-111 charge sensitive amplifier/ discriminator circuit and connections for high voltage, low voltage and signal cables. The detector modules are housed inside a 210 mm thick polyethylene outer shield that is covered in stainless steel. The internal and external module surfaces are covered in cadmium to absorb re-entrant thermal neutrons. This cadmium liner can be removed to increase the detection probability for coincidence and total counting.

Drums for measurement are loaded manually (drum lifter or forklift) onto a drum carrier which moves on slide rails. A drum is subject to a gamma ray measurement and then loaded into the measurement chamber for the neutron measurement in the following automatic sequence:

1. The drum is positioned on drum carrier, which is then rotated;
2. While the drum is rotating, the HPGe detector performs a helical scan of the entire drum during which time a gamma ray spectrum is acquired;
3. A gamma ray check measurement is made using the 356 keV line from a Ba-133 source installed in a shielded position below the drum carrier;
4. The Drum Monitor doors are opened using automatic linear actuators;
5. A slide rail “drawbridge” is automatically lowered into position linking the external slide rails (on which the drum carrier sits) to slide rails in the measurement chamber;
6. The drum on the drum carrier is moved into the measurement chamber by an electric motor driven “engine” which uncouples the drum carrier;
7. The drum on the carrier remains in the chamber and the “engine” withdraws to its original drum loading position external to the measurement chamber;
8. The slide rail “drawbridge” is automatically raised to its original position out of the chamber and clear of the doors;
9. The Drum Monitor doors are closed and the neutron measurement starts.

The ANTECH N2000 Universal Neutron Counter (UNC) is used for the neutron measurement data acquisition for both neutron coincidence and neutron multiplicity counting. For pair correlation counting in neutron coincidence mode the frequency histogram collected by the N2000 is used to generate the ‘Reals’ coincidence rates for each of the 16 modules. Each ‘Reals’ rate can be used with a multi-gate calibration function to determine the $^{240}Pu_{effective}$ mass from the total plutonium mass. For a wide range of Plutonium Containing Materials (PCM) such as PuO2 and PCM with unitary neutron multiplication (M=1), triple neutron correlation may be used in absolute multiplicity counting mode. In

these cases total plutonium mass and $^{240}Pu_{effective}$ mass are determined without the use of a calibration function and the matrix characteristics are determined from the measured detection efficiency.

A Safeguards HPGe detector with 20% detection efficiency (ORTEC SGD-GEM-5050P4) is housed in a stainless steel clad lead shield and collimator close to the rotating drum load position on a scanning mechanism. Digital DSPEC gamma ray spectroscopy data acquisition electronics is used for the Pu (and U) isotopic ratio measurement. The detector employs either liquid nitrogen (LN) or electromechanical cooling (ORTEC Integrated Cryocooling System (ICS)).

Features

- High neutron detection efficiency for coincidence and multiplicity counting with low background polyethylene shielding
- Safeguards quality >20% HPGe detector for Pu (U) isotopic ratio analysis
- Semi-automatic drum loading and unloading
- Automated measurement procedure employing user friendly Windows based Neutron Coincidence Counting and Neutron Multiplicity software incorporating analytical dead-time correction
- Instrument normally supplied with the ANTECH Model N2000 UNC with multiple gate neutron coincidence plutonium analysis software with including range calibration function
- ANTECH Model A2000 TTL-LVDS Convertor is included for integration with N2000 UNC
- Digital DSPEC gamma ray spectrum data acquisition electronics

Benefits

- Passive neutron coincidence counting with a suitable calibration
- Absolute passive neutron multiplicity assay (independent of sample matrix and without calibration) for appropriate PCM waste streams and sample types (M=1)
- Suitable for PCM waste with a high alpha ratio (alpha<10)
- Optimised for use with the ANTECH N2000 multiplicity counter electronics using 3 trigger methods and 16 simultaneous observation intervals (gate widths)
- N2000 input provides Individual totals count and statistical analysis for each of the 16 counting chains (each chain has a separate head amplifier)
- Dual technology (neutron/gamma) measurement system provides complete result in terms of Pu (and U) mass

Specification

External dimensions (H x W x D)		2100 mm x 1800 mm x 3300 mm
Neutron detectors		64 detector tubes, 25.4 mm x 1000 mm at 5 atmospheres (Cd shielded)
Neutron detector efficiency		20%
Neutron die-away time		68 ms
Neutron detector operating voltage		1600 V (5 atm, ^{3}He)
Typical neutron measurement time		20 minutes per drum
Gamma ray HPGe detector		>20% efficient Safeguards detector (ORTEC SGD-GEM-5050P4)
HPGe detector resolution at 30 kcps		at 122 keV: 890 eV, at 1.33 MeV: 2.10 keV
Typical gamma ray measurement time		5 minutes per drum
Gamma ray installed check source		1uCi (37kBq) Ba-133 source (reference gamma ray at 356 keV)
Neutron measurement estimated sensitivity at sea level	**Multiplicity counting (n triple correlation)**	50 – 100 mg $^{240}Pu_{effective}$ (Cd liner fitted)
	Coincidence counting (n pair correlation)	10 – 50 mg $^{240}Pu_{effective}$ (Cd liner fitted)