



Waste Crate Assay System (WCAS)

Passive Neutron Coincidence Counter



Nuclear



Healthcare



Homeland Security & Defense



Labs and Education



Industrial and Manufacturing

KEY FEATURES

- Combines multiple assay techniques
 - Passive neutron multiplicity coincidence counting
 - High resolution isotopic gamma-ray analysis
- Crate sizes up to 1660 L (1.4 x 1.4 x 1.2 m)
- Scalable to larger containers
- Fully automated operation and analysis
- 18% efficiency for ^{240}Pu fission neutrons
- MDAs of less than 6 mg ^{240}Pu
- Multiple HRGS detectors
- ^{252}Cf Add-A-Source moderator correction
- NDA-2000 Non-Destructive Analysis Software

DESCRIPTION

The Waste Crate Assay System (WCAS) is a passive neutron coincidence counter designed for low level waste assay to determine the transuranic (TRU) activity of contaminated solid waste in containers up to 1.43 x 1.43 x 1.20 m crates. The WCAS provides simultaneous passive neutron coincidence and high resolution gamma isotopic analysis allowing rapid characterization of plutonium wastes.

The WCAS is based on the CANBERRA Waste Drum Assay System (WDAS) design with integrated High Resolution Gamma-Ray System. Results from individual neutron and gamma-ray assays are combined automatically by the NDA-2000 software. Because the assays are performed in the same system in a single assay sequence there is no confusion over item ID or modification of sample contents between assays.

The system is designed to be operated as an automated counting system which can process batches of drums, or can be incorporated in a facility process line. The following sections describe the various assay sub-systems, hardware, software and indicate typical performance characteristics.

Components of the system include the neutron counter with ^3He detector, Amptek[®] based fast preamplifier/discriminator circuit boards (Model JAB-01), coincidence electronics, computer hardware, high resolution gamma detectors, digital signal processing for the gamma-ray analysis and application software.

The WCAS shield assembly provides a 4, 20 cm thick High Density Polyethylene (HDPE) moderator/shield as a measurement chamber for the drums and crates. The neutron shield provides an assay chamber that minimizes the effects of outside neutron radiation levels. As configured the neutron shielding is also effective for reducing the gamma-ray background levels (equivalent to a 1 in. thick steel shield) enhancing the performance of the MGA isotopic analysis at low Pu mass loadings.

The software converts the correct neutron coincidence rate to ^{240}Pu effective. The plutonium isotopic abundances are then calculated and used to convert the measured ^{240}Pu effective mass to a total plutonium mass.

Waste Crate Assay System (WCAS)

OPERATION OF THE COUNTER

The WCAS counter automatically loads and unloads drums into the assay chamber. The general sequence of events for the system in analysis mode is as follows:

1. The sliding door opens and the conveyor moves the crate into the assay chamber.
2. The sliding door closes.
3. Operator enters the pertinent information on the sample.
4. Add-A-Source movement is automatically controlled by the PLC and the matrix correction measurement is controlled by the software.
5. Passive neutron and gamma isotopic measurements are run simultaneously.
6. Upon completion of the assay the door opens and the sample automatically exits the counter.

Crate loading and unloading is provided by a trolley/conveyor mechanism. The trolley/conveyor system accommodates crates weighing up to 2000 kg and the cavity door is controlled by a Process Logic Controller (PLC) interfaced to the system computer.

PASSIVE NEUTRON ASSAY SYSTEM

The WCAS utilizes the same basic design parameters for passive neutron assay analysis as CANBERRA's High Efficiency Neutron Counter (HENC)¹. The passive neutron counting system uses 96 ³He proportional tubes arranged in a 4 counting geometry providing a total neutron detection efficiency of 18% for ²⁴⁰Pu spontaneous fission neutrons and a coincidence sensitivity of 13.4 cps/g ²⁴⁰Pu effective. This corresponds to a detection level of 64 mg weapons grade Pu (6% ²⁴⁰Pu) in 3600 seconds.

ADD-A-SOURCE (AAS) MATRIX CORRECTION

The Add-A-Source (AAS) technique provides a means of measuring the impact of the waste matrix on the neutrons emitted within the drum. In practice a small ²⁵²Cf source (about 100 000 n/s) is introduced into the assay cavity with no sample in the counter. The measurement is repeated after the sample is loaded and the results compared. The difference in the measured count rates can be used to correct the measured sample rate. The WCAS includes a dual position AAS matrix correction module.

An illustration of the AAS measurement is shown in Figure 2. The ²⁵²Cf source is normally stored in a shield module located to one side (or above) the counter. The source is automatically moved through a guide tube to the interrogation position and then retracted.

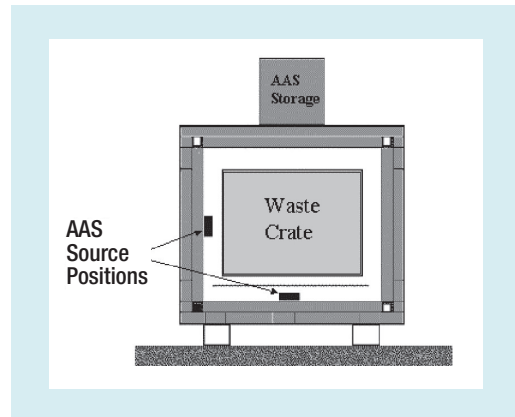


Figure 2.
Relative location of the Cf-252 source
interrogation position for the
WCAS Add-A-Source measurement.

For homogeneous distributions of Pu in the drum the AAS correction results in a typical error of $\pm 5\%$ from the expected values. Without the correction the errors can exceed 50%. The effectiveness of the AAS correction is illustrated in Figure 3.

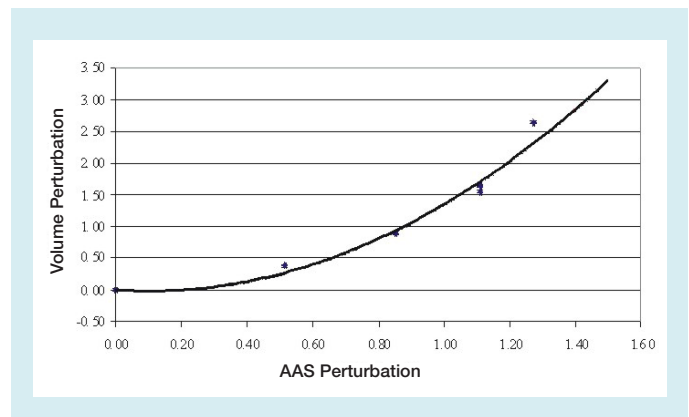


Figure 3.
AAS correction calibration results for the WCAS counter
for a series of homogeneous matrix crates with a simulated
uniform source distribution.

The assay cavity's neutron response was tailored to minimize variations in detection efficiency as a function of source location in the cavity. In order to provide a uniform neutron response within the assay cavity the counter door extends below the assay cavity floor. The linearity in response is illustrated in Figure 4.

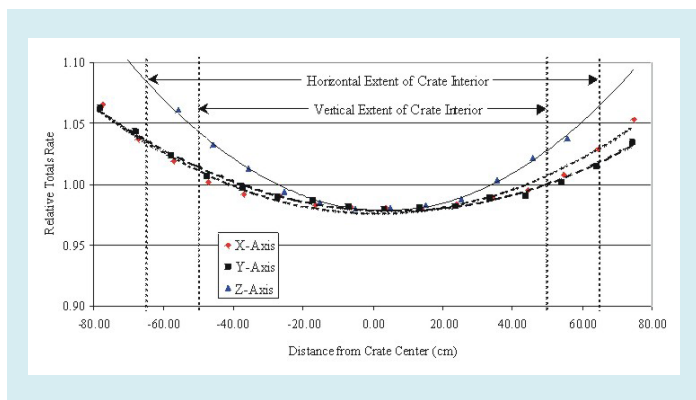


Figure 4 – Axial response profiles for the WCAS.

PASSIVE NEUTRON ANALYSIS BACKGROUND CORRECTIONS

The coincidence neutron background has two primary sources, the presence of nearby fission sources and cosmic-ray induced neutron events. The WCAS shielding is sufficient to remove much of the ambient neutron background but can not eliminate the neutrons generated by cosmic-rays interacting with the counter's body or the contents of the sample. Crates containing lead or steel have an associated cosmic-ray induced coincidence background (or interference) that results in a positive bias in the reported mass if not corrected. Conversely, highly moderating matrices (e.g. plastics) tend to attenuate the cosmic-ray induced coincident neutrons potentially resulting in a negative bias. The WCAS can correct for these effects using the NDA-2000 software.

The NDA-2000 software has a suite of correction algorithms available. The Matrix Based Background Correction (patent pending) will adjust the background rates based on the moderator content of the drum determined from the AAS measurement. The cosmic-ray rejection (CCR) algorithms include the typical truncation techniques but also a more sophisticated multiplicity analysis that can determine the high-Z material content of the drum and correct the measured coincidence rates (patent pending) for this effect and eliminate the bias.

GAMMA-RAY ASSAY SYSTEM

The gamma-ray assay system is based on CANBERRA's Q2 concept. Two high resolution germanium detectors are mounted on each side of the assay chamber protruding through the HDPE shield. The HDPE shielding serves to reduce the gamma-ray background improving the performance of the gamma isotopics measurement.

PLUTONIUM ISOTOPICS MEASUREMENT

The WCAS would typically be provided with CANBERRA's Broad Energy Germanium (BEGe) detectors. These detectors provide efficiency required for quantitative gamma measurements and the resolution required for the most sensitive plutonium isotopics codes such as the Multi-Group Analysis (MGA) software. MGA was developed at Lawrence Livermore National Laboratory by Dr. Ray Gunnink. CANBERRA's MGA code has been enhanced for waste assay applications and the complications resulting from poor counting statistics. This package can provide plutonium isotopics for very small sources in waste containers. In addition to the plutonium isotopics, it will determine other actinides such as ^{235}U , ^{238}U , ^{237}Np , and ^{241}Am . (Note: other isotopics codes such as the Los Alamos FRAM code are available upon request).

PHYSICAL

The overall dimensions of the passive active neutron counter are 422 x 486 x 286 cm (L x W x H). This foot print includes the requirements for the door in open position and the 240 cm long load conveyor. Overall weight of the counter is approximately 8000 kg.

REFERENCES

1. "The Design of a High Efficiency Neutron Counter (HENC) for Waste Drums to Provide Optimized Sensitivity for Plutonium Assay" H.O. Menlove, et.al., Proceedings of the 5th Nondestructive Assay and Nondestructive Examination Waste Characterization Conference". Salt Lake City, UT, January 14-16, (1997).
2. "Q2 – A Very Low Level Quantitative And Qualitative Waste Assay And Release Certification". F. Bronson, Proceedings of Waste Management '90, February 25-28, 1990, University of Arizona, Tucson, AZ.



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