MIRION TECHNOLOGIES

Radiation Safety. **Amplified.**

HENC

High Efficiency Passive Neutron Counter

Nuclear

Healthcare

Homeland Security & Defense

Labs and Education

Industrial and Manufacturing

KEY FEATURES

- 208 liter (55 gallon) drum counter
- >30% efficiency
- <0.7 cps coincidence background at sea level
- MDAs of less than 20 nCi/g
- Automated loading and unloading
- Add-A-Source correction
- Coincidence or multiplicity counting

DESCRIPTION

The High Efficiency Neutron Counter (HENC) represents the ultimate in CANBERRA's family of passive neutron coincidence counters. Combining a detection efficiency of over 30% with increased shielding to reduce backgrounds, the HENC is designed to assay 208 liter (55 gallon) drums to detection levels on the order of 1.6 mg of ^{240}Pu-effective in a 1000 second count time. With the addition of enhanced correction and analysis techniques such as Add-A-Source and multiplicity counting the HENC is also an extremely accurate assay system.

Components of the proposed system include the neutron counter with ^{3}He detectors, Amptek®-based fast preamplifier/discriminator circuit boards (Model JAB-01), coincidence electronics, computer hardware, and application software. The turnkey system is designed for ease of operation and minimal maintenance.

Spontaneous fission neutrons from the even isotopes of plutonium will be measured using passive neutron coincidence or multiplicity counting techniques. The neutron counter consists of a high-density polyethylene (HDPE) moderator with ^{3}He tubes embedded in theHDPEon all six sides of the counter with optimal spacing for maximum detector efficiency.

The software converts the corrected count rate to ^{240}Pu-effective (combination of ^{238}Pu, ^{240}Pu, and ^{242}Pu) and calculates the total measurement uncertainty.

The counter's neutron detection efficiency is 30% for ^{252}Cf neutrons emitted in the center of the assay cavity. The spatial response of the counter is uniform. Variations from the mean efficiency are less than 3% for totals (non-coincident neutrons). An optional drum rotator provides additional smoothing of non uniformities in response due to the rectangular shape of the assay chamber.

It is possible to reduce the matrix effects by the use of the Add-ASource (AAS) technique. An illustration of the AAS measurement is shown in Figure 1. The AAS introduces a small ^{252}Cf source into the sample chamber at the end of the passive assay and compares this result with an empty chamber value. The impact of the waste matrix is evaluated from this relative measurement and an appropriate correction is applied. The ^{252}Cf source for the AAS correction is stored above the counter in a HDPE shield.

CANBERRA

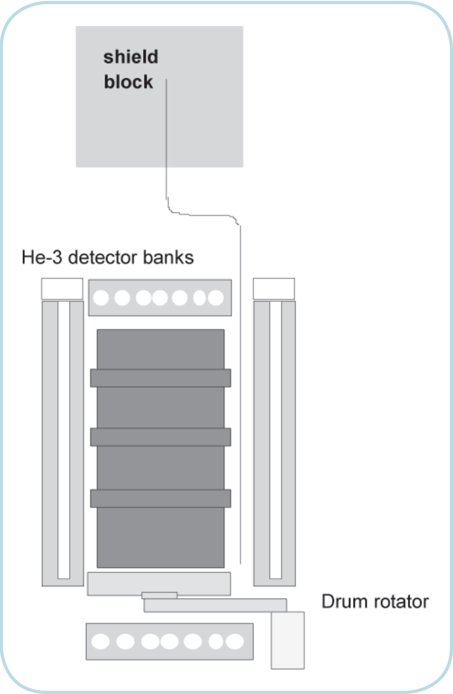

Figure 1 –
Schematic Diagram of the Side Scanning AAS.
(Other configurations are available).

Measurements indicate that the presence of the ^{252}Cf source has no significant impact on the background readings. The source positioning is controlled by the software.

OPERATION OF THE COUNTER

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

- Sliding doors open and drawbridge lowers into position. The conveyor moves the drum into the assay chamber.
- Drawbridge raises and the counter doors close.
- Operator enters the pertinent information on the sample.
- Rotation motor is switched on.
- A passive neutron count is performed for the preset time.
- Add-A-Source Option: Following the passive count the AAS measurement begins.
- AAS source movement is automatically controlled by PLC.
- Upon completion of the passive assay and AAS measurement, the door opens and the drawbridge lowers.
- Sample automatically exits the rear of the counter for two-door configuration or the front door for the one-door configuration.

SOFTWARE

The HENC systems are provided with CANBERRA's S430 Neutron Analysis Software. This software is based on our Genie™-PC platform. The assay data is stored in the standard CAM file format. This format stores all relevant information for the given assay including calibration parameters, raw data, results, error flags and QA check results. This ability to retain all data allows reanalysis of the data at a later time for accountability purposes or if any irregularities are uncovered. The software makes use of pull down menus and predefined parameter entry to simplify operation of the system.

PERFORMANCE

The counter is provided with a complete mapping of the chamber response. This data is useful in verifying the proper functioning of the counter and in defense of assay results. The extent of any positional variation is fully documented at delivery. This variation is less than ±5%. The accuracy of a given measurement is determined primarily by the following factors:

COUNTING STATISTICS

The statistics are typically associated with the precision of the assay. The limits on the precision are count time, efficiency, SNM content, and background. The HENC has an advantage over other passive neutron counters because of its higher efficiency and lower background response. The lower background is derived from additional poly shielding and superior electronics. The background of the HENC is typically half that of other counters of the same size and efficiency. This leads to lower limits of detection for the CANBERRA drum counters.

The Lower Limit of detection of the counter at sea level with no additional overhead shielding is 1 to 3 mg of ^{240}Pu-effective corresponding to 3 to 10 mg of high burn-up Pu. This value is quoted at the 3-sigma level corresponding to about ±33% at one sigma. For Pu contents exceeding 1 gram this uncertainty drops to about 3.5% and at 30 grams Pu this further decreases to less than 1%.

UNIFORMITY OF THE CHAMBER RESPONSE

The variation of the response with source location in the chamber can have a significant impact on the assay results. The flat response of the HENC, combined with the averaging effect of the turntable, essentially eliminates this effect for most sample matrices. The RSD variation in response for the HENC is approximately 2% throughout the normal sample volume.

MATRIX EFFECTS

Neutron counters are most impacted by the hydrogen content of the sample. Samples containing significant quantities of water or oil can be significantly impacted. This impact is seen as a lowering of the neutron response. The HENC counter includes the AAS Matrix correction option to reduce this effect.

DISTRIBUTION OF THE Pu IN THE DRUM

For homogeneously distributed samples, the AAS correction is highly accurate, providing values of ±2% (not including the effects of counting statistics). However, drums containing large quantities of hydrogen and localized concentrations of Pu will incur larger errors due to positioning effects.

Overall accuracy for a typical drum with a hydrogen content less than 10% of water (e.g. paper and process clothing) will be better than 20% for a sample with more than 1 gram of high burn-up Pu. (For samples with greater than 1 gram high burn-up Pu the counting statistics become negligible compared to other sources of error.)

MULTIPLICITY OPTION

The multiplicity analysis option provides a correction for large Pu concentrations and for high alpha-n samples. The multiplicity analysis is already built into the NAS software. Where coincidence counting measures total neutron and coincidence events, multiplicity analysis records the frequency of occurrence of various neutron multiplicity events (i.e. whether 1, 2, 3 up to 128 neutrons were detected for any given event). This allows the determination of singles, doubles, and triples rates providing an extra parameter so that values for alpha, multiplication and ^{240}Pu-effective mass may be determined from the assay. This feature reduces the error introduced from the unknown sample isotopics or from concentrated Pu masses.

MULTIPLICITY FOR WASTE ASSAY

For traditional waste assay, the total fissile mass is often less than a few grams. For these samples, the multiplication is essentially one and the value of alpha has little impact on the assay. Multiplicity analysis provides two possible benefits over standard coincidence counting for waste assay. The analysis allows a measurement of the counter efficiency by assuming M=1 and solving the rate equations for ^{240}Pu-effective mass, the value of alpha, and the efficiency. In practice, the precision of the triples rate in these situations is poor and the precision of the overall measurement is decreased. However, LANL publications indicate that this result is more accurate than if determined by coincidence counting. In other words on average the results will be closer even if the statistical error is larger for a single assay.

ADD-A-SOURCE OPTION

The Add-A-Source (AAS) technique provides a means of measuring the impact of the waste matrix on the neutrons emitted within the drum. For homogenous distributions of Pu in the drum the AAS correction results in a typical error of ±2% from the expected values. Without this correction the errors can exceed 50%. The effectiveness of the AAS correction is illustrated in Figure 2.

It should be noted that the AAS assumes a uniform source distribution. When a point source is placed in a drum with high moderator content the positioning effects increase. However, experience has shown that for drums containing the equivalent of less than 40 kg of water will result in errors of less than 10% after the AAS correction is applied.

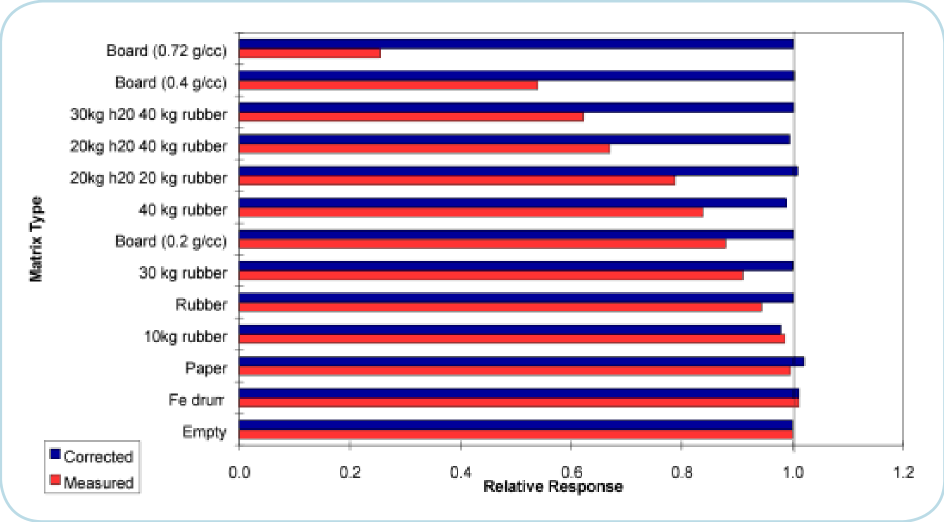

Figure 2 – AAS correction example for a HENC counter.

SPECIFICATIONS

DIMENSIONS

- LENGTH – 362 cm.
- WIDTH – 195 cm (not including drawbridge).
- HEIGHT – 270 cm.
- WEIGHT – 8200 kg.

CONVEYOR

- HEIGHT – 62 cm.

^{3}HE TUBES

- NUMBER – 113.
- DIAMETER – 2.54 cm.
- PRESSURE – 7.5 atm.

CANBERRA