RADIOLOGICAL AND HAZARDOUS MATERIAL MEASUREMENT SYSTEM*

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ABSTRACT

Existing nuclear waste assay systems do not have the measurement threshold or volume production rate capabilities required for a meaningful remediation of the significant amounts of nuclear waste at many of the DOE facilities. The conceptual design of the Radiological and Hazardous Material Measurement System, (RHMMS) was in response to engineering requirements for the remediation of uncharacterized, buried nuclear waste in the Radioactive Waste Management Complex (RWMC) at the Idaho National Engineering Laboratory (INEL).

The RHMMS is an integrated, multi-measurement processor with projected capabilities of measuring fissile and fertile materials to threshold levels below 10 nCi/g, at a volume production rate approaching 300 barrel equivalents per day. The processor also has the waste refinement capability of removing material which exceeds transuranic (TRU) levels from the bulk waste material.

This paper addresses only the development of the measurement systems required for characterizing the waste.

RHMMS PROJECT OBJECTIVE

The RHMMS project objective is to develop an integrated measurement system that will accurately measure TRU and other radioactive and hazardous material in waste.

RHMMS REQUIREMENTS

a. Minimize the amount of waste that must be classified as TRU by accurate measurements of the material and the application of appropriate correction factors to compensate for signal matrix modifications in the raw data.

b. Make the measurements at production rates required for a meaningful remediation program.

c. Measure waste from pits and trenches that can no longer be characterized.

d. Measure intact barrels.

RHMMS SYSTEM DESCRIPTION

The complete measurement system is shown in Fig. 1. The cells being developed are shown in the dashed oval. This is the portion of the system that is described here. The remaining equipment consists of commercially available units that only need to be customized to accommodate the measurement cells.

These measurement cells are:

- Gamma screen
- Passive gamma cell
- Passive-active neutron cell
- Capture gamma cell (hazardous material monitor)
- Supplementary Cells.

The data accumulated by these cells provides the identification, quantification, and characterization of waste containing:

- Transuranics
- Fission products
- Activation products
- Heavy metals
- Neutron absorbers
- Neutron moderators
- Gamma attenuators.

Gamma Screen

This cell requires very little development effort. It consists of plastic scintillators or sodium-iodide detectors. This is a high sensitivity-low resolution gamma measurement system. Its primary purpose is to determine if any gamma emitters within a waste package can be detected by the sensing system of the passive gamma cell. This will allow the operators of the system to bypass that cell if gamma radiation is insignificant. The passive gamma cell requires the most time to obtain adequate statistical data. The throughput of the entire system can be enhanced if those waste packages without sufficient gamma ray emission for source identification can bypass this cell.

This is an inline measurement. The waste is stepped through the detector field incrementally, momentarily stopped while data is collected from the sensors and then passed on to the next cell. It not only detects the presence of a source but will also provide its general location within the package to the data acquisition system.

Passive Gamma Cell

The detectors in this measurement cell are high purity Germanium detectors. Although not as sensitive as the detectors of the gamma screen they have a much better energy resolution. Using gamma ray spectroscopy, the gamma ray energy signatures can identify radioactive sources in the waste. The relative intensities of the energies peculiar to a

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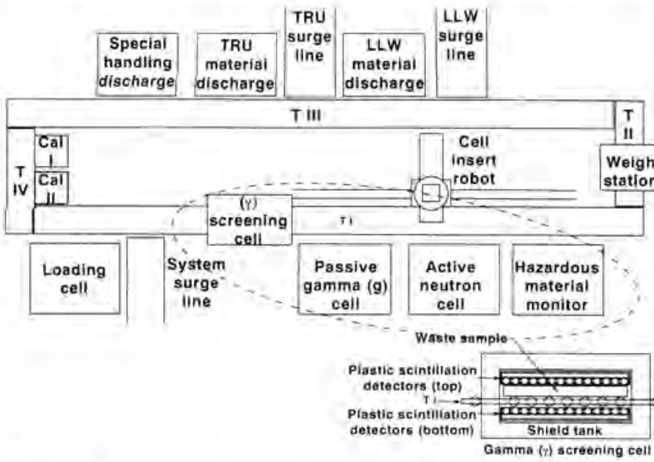

Fig. 1. Radioactive waste measurement and refinement system.

particular source can also be used to estimate the attenuation of the materials between the detectors and the gamma source.

The waste package will be placed in the shielded gamma cell. There it will be passed between rows of sensors in four to eight steps depending on the intensities of the sources encountered. It will remain in each position for 50 seconds while data is accumulated.

Passive-Active Neutron Cell

This cell uses Helium-3 and Helium-4 detectors in orthogonal arrays placed on one side of the waste package. A variable moderator and the neutron source are located on the other side. The passive neutron count will first be made. The neutrons produced by spontaneous fission of Plutonium isotopes and the alpha, neutron reaction from the decay of alpha producing nuclides will be measured. Although the He-4 detectors are less sensitive than the He-3 detectors they only respond to neutron energies that are higher than the neutrons that will be used in the active neutron interrogation so they do not need to be turned off during the interrogating neutron pulse.

The active neutron interrogation system uses an ACCSystems PL-2 proton accelerator with a metal foil target (Lithium) to produce low energy neutrons, (80 to 120 keV). This system provides 1000 times more interrogating neutrons than existing systems using the Zetatron, which produces 14 meV neutrons; so shielding and moderation requirements are both improved. This then provides higher sensitivities and faster measurements than the old systems. This measurement is most accurate for low levels of TRU and will be able to detect radioactive levels below 10 nCi/g in a waste package.

Capture Gamma Cell

All of the above measurements are not only effected by the waste package size (thickness) but by the different non-radioactive constituents that are intermixed. By again interrogating the waste package with low energy neutrons, but blocking the emitted neutrons from entering high-purity Ge detectors, many elements that effect those measurements, as well as several hazardous elements that have significant neutron capture cross sections, can be identified and quantified by their gamma energy signatures.

These include:

- Arsenic
- Barium
- Boron
- Cadmium
- Chlorine
- Chromium
- Hydrogen
- Lead
- Mercury
- Selenium
- Silicon
- Silver.

By integrating all the data from the different cells in a central data acquisition system, a higher degree of accuracy and confidence is obtained than by using any single measurement alone. Indeed, past experience with present systems has proven the need for a multiple measurement system.

Supplementary Cells

Other measurement cells can be readily added to the RHMMS such as RTR or gamma ray tomography. These systems are already developed or are being developed at other national laboratories. Another cell using higher energy interrogating neutrons could also be added to determine the U-238 present within a waste package. The inclusion of these cells would add another measure of confidence in those being developed here.

CONCLUSION

The multiple measurement system briefly described here is the only system presently being developed that can identify, quantify, and characterize radioactive and hazardous materials retrieved from pits and trenches with sufficient resolution and accuracy to allow separation of overburden,low level and TRU waste. This separation capability can save millions of dollars in a retrieval operation. A more detailed description of the RHMMS is available in the reference report (1).

REFERENCE

1. T. B. KLINGLER, "Radiological and Hazardous Material Measurement System," EGG-WM-9186, Rev. 1, EG&G Idaho, Inc., November 1991