4.3 Portable X-ray, K-edge Heavy Metal Detector

Technology Needs

Cleanup of many DOE facilities requires dismantling equipment that was used to process hazardous materials such as uranium, plutonium, and mercury. Using existing techniques, such as passive neutron and gamma measurements and neutron activation analysis, it is difficult and time consuming to detect and quantify these hazardous materials when they are contained within heavy equipment (i.e., steel pipes with 1/2" thick walls). The gaseous diffusion plant at the K-25 Site at Oak Ridge contains over 100 acres of heavy equipment used for separating uranium isotopes. Similarly, the Fernald Site has buildings and equipment used in processing uranium ore. Rapid in situ analysis of these types of equipment for hazardous elements is needed to improve the efficiency and safety of D&D efforts.

Technology Description

The K-edge technique provides an improved method for detection and quantification of heavy metals, such as Hg, U, Pu, located inside containers and equipment. An X-ray transmission measurement of the K-shell absorption edge of these materials is implemented in this task. This method provides accurate quantification of these elements regardless of container material and geometry. Typical accuracy of 10% for 10 mg/cm^2 of heavy metals in one inch of steel (100 ppm) is achievable. Figure 4.3-1 shows an example of a K-edge absorption spectrum for 11 mg/cm^2 U inside a steel pipe with 1/2" thick walls. A fieldable prototype instrument is being developed, and will be tested at DOE sites in support of the D&D Focus Area.

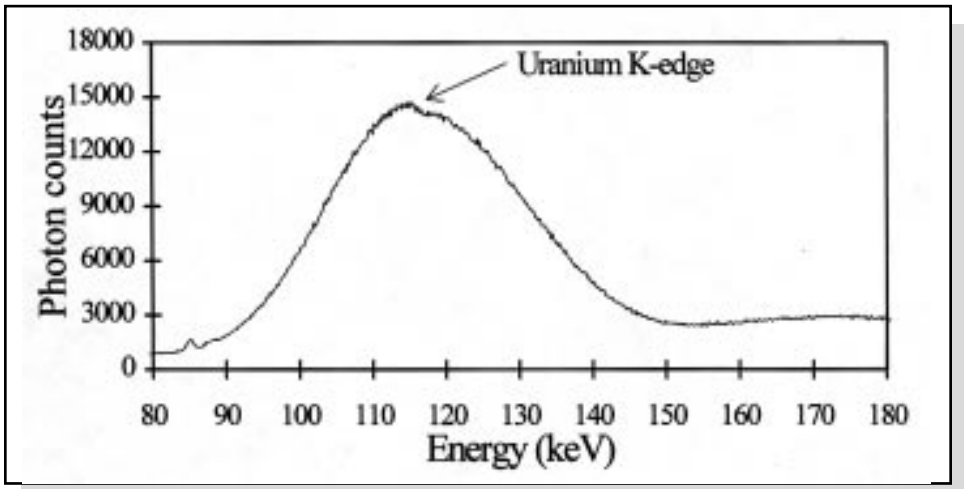

Figure 4.3-1. K-edge absorption spectrum for uranium in a steel pipe.

Benefits

A fast in situ method for quantifying the presence of uranium, plutonium, and RCRA-listed heavy metals inside closed containers would greatly enhance the safety and efficiency of D&D efforts. In particular, there are residual deposits of uranium found in gaseous diffusion plant equipment and in ore refining facilities. Not having to dispose of process equipment as high-level waste would yield significant savings. Accurate determination of the level of hazardous metals present would enhance the safety of dismantling operations.

Collaboration/Technology Transfer

This project is currently being carried out at Iowa State University and Ames Laboratory, taking advantage of existing expertise at the Center for Nondestructive Evaluation. In development of the prototype instrument, we have worked with several companies to produce specialized components. Based on this work, we anticipate further collaboration with industry to optimize equipment to meet the needs of the technique.

Accomplishments

- Measurement of 1.3 μm (2.5 mg/cm^2) gold in 1/2-inch steel
- Measurement of 2 μm (4 mg/cm^2) uranium in 1-inch steel
- Measurement of plutonium in vitrified sample
- Prototype fieldable instrument designed

TTP Information

Portable X-ray, K-edge Heavy Metal Detector technology development activities are funded under the following Technical Task Plan (TTP):

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Bibliography of Key Publications:

Aljundi, T., T. Jensen, J.N. Gray, and D. Robinson. "Heavy Metal Detection Using X-Rays," to be published in *Reviews of Progress in Quantitative Nondestructive Evaluation*, Vol. 15, edited by D.O. Thompson and D.E. Chimenti (1996).