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ELECTROMAGNETIC-COIL (EM-COIL) MEASUREMENT TECHNIQUE TO VERIFY PRESENCE OF METAL/ABSENCE OF OXIDE ATTRIBUTE

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This paper summarizes how an Electromagnetic-coil (EM-coil) measurement technique can be used to discriminate between plutonium metal and plutonium oxide inside sealed storage containers. As evidence, measurements on a variety of metals and their oxides are presented. This non-radiation measurement method provides assurance of the "presence of metal/absence of oxide" attribute in less than a minute.

During initial development, researchers at Pacific Northwest Laboratory have demonstrated the ability of this method to discriminate between aluminum and aluminum oxide placed inside an AT-400R storage container (total stainless steel wall thickness of over 2.5 cm). Similar results are expected, since Pu metal is electrically conductive and a Pu oxide behaves as an electrical insulator. At this writing, work is underway to perform the same demonstration using plutonium and plutonium oxide. Similar success has been demonstrated when using ALR-8 storage containers (basically carbon steel drums).

Within these container types two scenarios have been explored. 1.) The same configuration made from different metals for demonstrating material property effects. A clear distinction was seen between the slight alloy changes among various forms of aluminum and brass in the same configuration. 2.) The same metal configured differently to demonstrate how mass distribution affects the EM signature. Hundreds of bb's (each about 2 mm in diameter) were placed in different containers to show how a slight change in distribution will affect the EM signature. With a five percent change in bb container diameter, the resulting EM signature changes are clear.

This measurement method offers an extremely wide dynamic range resulting from its sensitivity to the wide range in electrical conductivity and magnetic permeability found in most metals and alloys. In fact, electrical conductivity spans the widest spectrum of all the known physical properties. Most insulators such as the oxides cover the range between 10^{-6} and 10^{-20} mhos/meter, while the metals and alloys typically span a range between 7×10^{7} and 5×10^{5} mhos/meter. Measurements have been made using materials spanning both ends of each range.

The EM coil method operates on the basis of Faraday's Law of induction. An alternating low-voltage signal is applied to an encircling coil at a selected frequency, generating a magnetic field at a storage containers surface. An electric field, of the same frequency, is generated in all metal objects placed inside the coil. The intensity of this electric field diminishes with depth into a metal. This electric field then causes electric current (commonly referred to as eddy current) to flow throughout conductive objects. As these induced currents flow they also generate a secondary magnetic field causing the coils impedance to change in proportion to the total magnetic field passing through the coil. A high-precision, impedance measuring device can monitor the coil's impedance and thus obtain an electromagnetic signature for all conductive objects placed inside the coil. The EM-coil is inherently less intrusive than a radiation measurement since it is sensitive to the combination of configuration and composition. On a mathematical basis, component information cannot be extracted from this measurement because the coil impedance is a two-parameter quantity and the number of parameters affecting the coil impedance is much greater than two.

The EM-coil method can make a determination that a container does or does not enclose metal in the expected configuration. Radiation detection methods on the other hand may only be able to establish the lack of oxide, which thereby implies the presence of metal, a weaker statement.

The EM-coil data analysis is extremely simple, requiring the definition of a region of interest in a two-dimensional plot. The EM-coil method is able to make a measurement in less than a minute, whereas radiation measurement methods demonstrated to-date have required counting time approaching one hour to make a reliable determination.

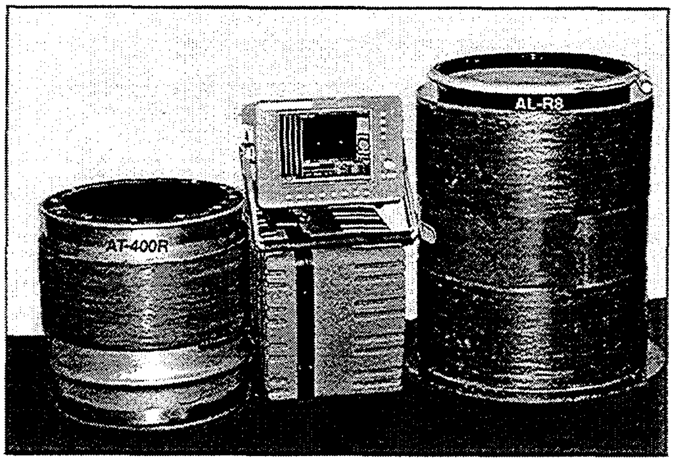

FIG. 1. EM-Coil System used with AT400R and ALR-8 Storage Containers