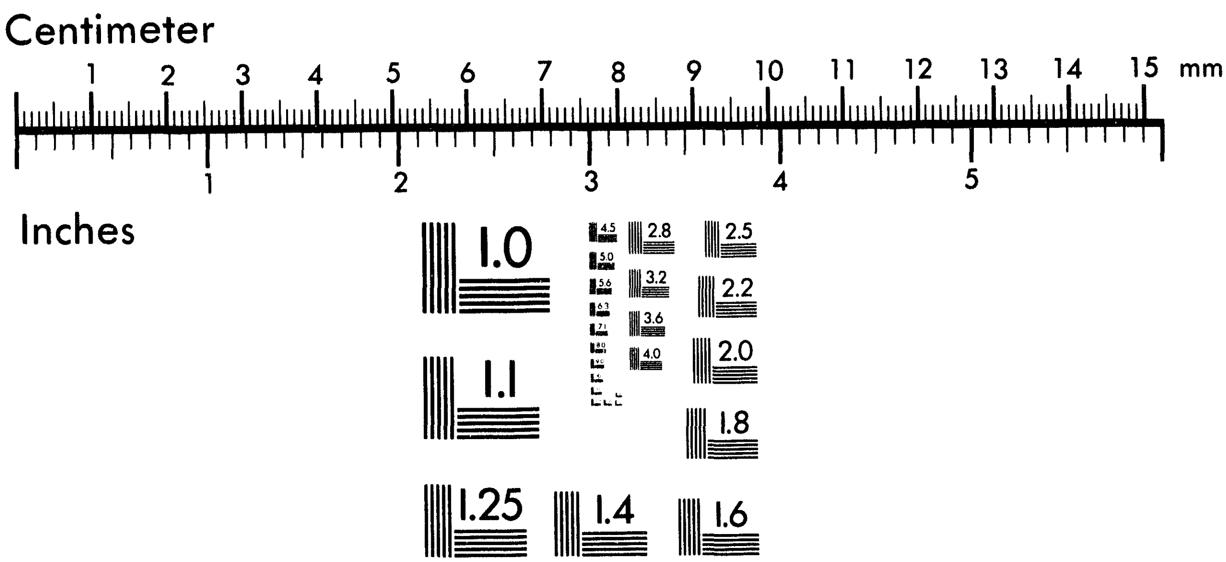
AIIM

Association for Information and Image Management

1100 Wayne Avenue, Suite 1100
Silver Spring, Maryland 20910
301/587-8202



MANUFACTURED TO AIIM STANDARDS
BY APPLIED IMAGE, INC.

Some Ideas for Next-Generation Controlled Nuclear Materials Accountability Techniques

Winslow Brough and Chuck Parrish
Lawrence Livermore National Laboratory

Abstract

Current DOE regulations for Controlled Nuclear Materials (CNM) management have particular accounting problems that have become more evident as computer systems have been designed and programmed to automate the materials accounting functions. Some valuable detailed accounting information is lost with current accounting procedures and some aspects of the procedures are more complicated than need be. In February, 1988, we first recommended that the basic concepts of CNM accountability be reviewed, with particular emphasis on developing an Isotopic accountability system as opposed to the present Material-type accountability system. A parallel effort to review the materials measurement program would also be desirable.

Material Types

The present accounting procedures for nuclear materials, both Special Nuclear Material (SNM) and Controlled Nuclear Material (CNM) identify the material by "Material Type". Material Type is an artificial term that roughly corresponds to isotope, but is not technically precise. For example, the difference between Material Type series 10 and Material Type series 20 (both Uranium-235 and Uranium-238) is the enrichment of Uranium-235 (percent U-235). In another case, Material Type 50 series, which is primarily Plutonium-239, includes three isotopes of plutonium (Pu-239, Pu-240 and Pu-241). In other cases, there is a one-to-one correspondence between Material Type and accountable isotope. Material type 86 is used for both deuterium gas (if element weight = 0) and heavy water (element weight is heavy water weight).

Accounting for CNM by "Material Type" identifies the major element and the major accountable isotope. This works well as long as the CNM isotopic ratios of an item do not change. Typically, when CNM is worked to produce manufactured parts for assemblies, the metal is cut or combined in such a way that the isotopic ratios of the products have the same ratio as the source material (feedstock). This is how most material has been worked, and has not created material accounting problems under the current regulations.

Technologies such as Laser Isotope Separation create a problem for CNM accountability systems, as previously unknown or irrelevant quantities of CNM isotopes for a given Material Type can now be separated out from the material. When a CNM item with a known Material Type is 'cut' by isotope, it creates an accounting problem that is further complicated by the 'reportable units' standard.

Reporting Units

Actual accountability of weights is performed in integer 'reporting units'. Each reporting unit, whose definition may vary from one Material Type to the next, represents some number of grams. In many cases, one reporting unit equals one gram, but in other cases ranges from one microgram to a kilogram. One is accountable for every reporting unit of material. Reporting units are obtained by rounding the accountable weight of a part into an integer. For example, 0.501 grams of plutonium is reported as 1 reporting unit; 0.499 grams of plutonium is not reportable and thus not accountable.

There are two accountable quantities associated with each Material Type. The "element weight", in most cases, is the total weight of the accountable element (e.g. uranium or plutonium) for a Material Type. The "isotope weight" is the weight of the primary isotope(s) (e.g. Pu-239 + Pu-241 for Material Type 50) for the Material Type. Both are expressed in integer reporting units.

The rationale for establishing these reporting units is unknown. Perhaps it was a limitation with punched-card systems; there wasn't enough space to report anything more than a small integer number on the cards (no decimal points or measuring units)? It could have been to establish a required accuracy in measurements, or to avoid having to track many small samples that would make accounting cumbersome. Or it could have been to keep track of just the 'significant' quantities, where 'significant' was defined by the monetary value or hostile threat which would result from not detecting losses because of poor or too coarse measurements.

With today's computer systems, there is no practical limit on the amount of information that can easily be stored and retrieved. Today's challenge is to understand what the data is saying—what is happening with the material, and is any of it significant with respect to loss or diversion of that type of material?

With the current reporting units, and today's materials accounting techniques, it can be confusing to understand all the losses and finds that appear on the books from the recovery and amassing of unreportable quantities of material and the use of isotope separation technology. Why not allow for more accurate and complete information in the accounting system and report what is known, rather than summarily dismissing it because it is "insignificant" or because it's not a major isotope for a particular Material Type?

MEASUREMENT UNCERTAINTY

One of the key elements of an accountability system is the retention and use of measurement uncertainty. Unlike a bank accounting system where the "inventory" can be "measured" (by counting) with absolute certainty, book element and isotopic weights are always estimates or approximations. Following a split transaction, the reported weights are estimates either by the operator or the computer system. The estimates may be replaced by measurements, but those data reflect inaccuracies of the measuring devices and are still estimates in a sense. All measurements have uncertainties associated with them. Knowing these uncertainties may be useful to:

1. **Help determine the total amount of material in a location for criticality purposes.** Currently, one simply adds up the element weights of the parts and compares the total weight to the mass limits. If uncertainties are included in the calculation, one is likely to err on the conservative side. For example, if 'x' is the total inventory weight, 's' is the total inventory uncertainty and 'y' is the mass limit, then we can say that the mass limit is exceeded if '$x + f(s) > y$', where '$f(s)$' is some function of the total uncertainty. This '$f(s)$' provides a margin of error (and thus safety) in criticality tests.

2. **Evaluate inventory differences.** An inventory difference is the difference between the inputs to a process and its products. Uncertainties are used to statistically test whether an inventory difference is significant (i.e., material was lost or stolen) or not significant (i.e., measurement round-off error, etc.).

3. **Evaluate shipper-receiver differences.** When material is moved between facilities (e.g. MBAs) the receiver may measure the material's composition and compare it with the book value, which is presumably derived from shipper's measurements. Uncertainties in both the book and receiver's measurements are used to test to assure that differences are due to differences in the shipper's and receiver's measurement devices.

RECOMMENDATIONS

There is no need to artificially classify material by Material Type; a natural classification by isotope should be incorporated. Material Type information can always be derived from isotopic information. The converse is not true; all isotopic information cannot be derived from Material Type information. Having an isotopic-based accounting system would provide a database much superior to the current Material Type database.

The Special Isotope Separation Materials Accountability Supervisory System (SIS MASS) here at LLNL does isotope-based accountability, for several reasons:

1. Since SIS MASS deals with an isotope separation process, information in the accountability system can be used to evaluate the performance of the process.

2. Isotopes are more natural to the user than Material Type. Users (ranging from handlers in the laboratories to technologists in the Materials Management office) do not need to know conversion algorithms in order to supply accounting information.

3. SIS MASS can obtain isotopic data directly from Non-Destructive Assay techniques. In all cases, this information also includes measurement uncertainty.

In addition to doing isotopic-based accountability, SIS MASS has provisions for retaining uncertainties. Currently each uncertainty is broken down into three components: Random error, short term systematic error and long term systematic error. How to break down any given uncertainty into these components and how to use these components to perform the above three tasks has not yet been determined.

It is our recommendation that this system be evaluated as a model system on which to base a next-generation federal accounting system for all CNM, and that DOE regulations be modified to require an isotopic-based accounting system at all facilities involved with CNM.

In addition, it is recommended that the measurement control techniques for CNM be modified to allow for reporting more detailed measurements when available and that measurement uncertainties be ascertained.

It is our opinion that the above two recommendations must be implemented before any significant progress can be made in improving data analysis techniques for detection of losses and diversion of CNM. Until better data are available, analysis techniques will suffer.

Currently, there are no known projects that we are aware of that are addressing these issues on an agency-wide scale.

DATE
FILMED
9/30/94

END