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Plan for the Purchase of MCT and EDS Reference Materials, Source Filters, Cu Strips, and Carousel Sub-Assemblies

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Plan for the Purchase of MCT and EDS Reference Standards and Materials, Filters, Cu Strips, and Carousel Sub-Assemblies

April 16, 2013
Version 3a

Objective:

Purchase reference standard, filter, and copper (Cu) strip sets for 10 Micro-CT (MCT) and 12 Explosives Detection System (EDS) systems (including 5 MCT and 3 EDS sets each for unplanned future systems/spares). This effort also includes the redesign and assembly of 10 carousel sub-assemblies for the MCT systems. The overall cost and time estimate for this plan is $279K and 31 weeks.

Goal

The goal of this effort is to improve the quality and consistency of MCT and EDS data across the program. New references, aluminum (Al) and Cu filters, and Cu strips will be of known high purity and quality, traceable to documented chemical analyses. A single Program organization will be responsible to purchase, fabricate, assemble, inspect, control, and supply these items to the Program to ensure adequate and uniform quality and quality control.

Background:

Reference standards are used in the home made explosives (HME) detection programs to monitor system performance, and to provide known standards to calibrate the response of the MCT and EDS systems. Other critical materials are used in the MCT systems (x-ray source filters and spectral monitor Cu strips). Existing reference standards, filters, and Cu strips are not made from high purity, traceable materials. The exact composition of most of these materials is either not specified or, in some cases, not well known, thereby impacting the accuracy of the measurement process. Because the effective-Z of the HME samples is interpolated from the references, any inaccuracy negatively affects the measurement.

The MCT systems use x-ray source filters placed on the front of the tube head that help define the system energy spectrum. Some of the filters are currently made from 2-mm thick 6061 Al alloy and Cu; however, not all of the filters in the Program are the same and may have varying material makeup and thickness. A Cu 1.26-mm copper strip on the front of the detector provides a transmission monitor during data acquisition to track unwanted variations in the x-ray source energy spectrum. These materials do not have specified tolerances for areal mass or uniformity and may differ from lab to lab.

To provide better consistency and knowledge of the MCT system, we propose to specify and supply the x-ray source filters and Cu strips for all MCT systems, label, and control them.

The reference materials, x-ray source filters, and Cu strips are used on multiple MCT/EDS systems. It is important for measurements, and thus for critical hardware, to be consistent between these systems. Both composition and density must be reproducible for use in future systems. For the reference materials, the composition is the more critical parameter, because it provides the effective-Z material-composition index. Also, the density appears as an energy-independent scalar so that variations can be more easily backed out of the analyses. Both attributes are, however, important. For filters and copper strips, uniformity in areal density and consistency in composition from sample to sample are essential.

Reference 1 provides additional detail on the history of these materials, and the basis for current selection of these materials for purchase under this plan.

This plan implements the requirements of Reference 2, *Control of Reference Standards and Materials*.

Table 1 lists the proposed reference standards, filters, and Cu strips to be purchased/fabricated under this plan.

Table 1. *List of proposed reference standards, filters, and Cu strips for the MCT and EDS systems.* [Ref. 1]

Material**	Purity/Spec.	Micro-CT*	Pelican Case 1b	Pelican Case 2b
Graphite	99.99+%	.5”x1.25” rod	2”x6” bar	2”x6” bar
Delrin®	100 NCO10	.5”x1.25” rod	2”x6” bar	
Water	Type 1 Reagent Grade/ASTM D1193	4 ml bottle (Nalgene® 2103-0002)	250 ml bottle (Nalgene® 2103-0008)	250 ml bottle (Nalgene® 2103-0008)
Teflon®	60x series	.5”x1.25” rod		2”x6” bar
Magnesium	99.95%	.5”x1.25” rod	2”x6” bar	
Silicon	99.999%	.5”x1.25” rod		2”x6” bar
Al filter	99.99%	4”x 4”x 2 mm		
Cu filter	99.9+	4”x 4”x 2 mm		
Cu strip	99.9+	1”x4”x 1.25 mm		

* MCT reference standards will be assembled into a carousel sub-assembly, which is a configuration item.

** Standards and filters will be labeled/bagged and tagged with a serial number, to provide traceability.

Task 1: Specify and design reference standards, filters, and Cu strip

This task includes activities for providing specifications for the materials used for the reference standards, filters, and Cu strips and documenting these on engineering drawings. The drawings will also

include dimensions, tolerances, labeling instructions, and other important details. The drawings will be also be used as the basis for the procurement, fabrication, assembly, and inspection of these items. Note that requirements for the radiography must be included in the design. In the case of the copper-strip radiography, and possibly for the imaging-filter this may require purchasing additional material.
Personnel: 1.5 FTE
Time: 80 hours
Labor: $30k
Material & Supplies: $0
Est. Cost: $30K

Task 2: Re-design carousel sub-assembly for the MCT systems

This task includes activities related to the creation of drawings/drawing revisions for the MCT carousel sub-assembly. The improved carousel sub-assembly will be a configured item, designed to meet the current and planned future needs of the Program. Design changes to the carousel include a modified top plate to better hold samples, plus other improvements.

Personnel: 1 FTE
Time: 80 hours
Labor: $20k
Material & Supplies: $0
Est. Cost: $20k

Task 3: Procure, fabricate, and assemble reference standards, filters, Cu strips and carousels

This task includes activities related to procuring, fabricating, assembling, and inspecting reference standards, filters, Cu strips and carousels, as applicable, for 10 MCT and 8 EDS systems. Procurement activities involve selecting the supplier(s) and placing orders. The supplier for the materials may also fabricate and label the items to drawing requirements, or the materials may be fabricated and assembled into final finished items or assemblies at another vendor or in-house. 24 Pelican™ cases will be purchased, modified, and assembled with reference standards, modified hinge pins, and foam inserts.

Personnel: 2 FTE
Time: 220 hours
Labor: $110k
Material & Supplies: $40.5k
Est. Cost: $150.5k

Task 4: Inspection, record keeping, storage, and shipping

This task involves the receipt inspection (e.g., to confirm quantity, no damage, correct materials, labeling, conformance to certifications, etc.) of the completed reference standards, filters, Cu strips, and carousels, creating and maintaining a tracking/inventory database for these items, maintaining the traceable records (e.g., chemical analyses), storing spares, and packaging and shipping these items to

Program participants. This task also covers performing and documenting chemical analyses of the materials. While documented chemical analyses will be specified in procurement documents for these items, it is anticipated that we will not be able to obtain such analyses for the plastic references from the suppliers. It may also be necessary to perform chemical analyses as part of the inspection/verification process for these items.

Personnel: 1.5 FTE
Time: 80 hours
Labor: $30k
Material & Supplies: $3.5k
Est. Cost: $33.5k

Task 5: Scan reference standards and perform radiography on copper-strips and filters

This task involves scanning all reference standards in the LLNL MCT and EDS systems. The scanning activity involves the physical x-ray scan, reconstruction, analysis, quality control, and reporting. MCT reference standards will be scanned as part of the complete carousel sub-assembly. This task also includes radiography of the copper strips, spectral filters, and radiography filters to verify that they are homogeneous and free of voids and/or impurities. Records of the CT and radiographic results shall be documented and archived. The data acquisition requirement for evaluating the Reference Standards, X-ray Source Filters, and Copper-Strip material is described in Appendix B.

Personnel: 2 FTE
Time: 540 hours
Labor: $45k
Material & Supplies: $0
Est. Cost: $45k

Project Deliverables

The overall project deliverables include:

1. Drawings for reference standards, filters, and Cu strip; and carousel sub-assembly/components
2. 10 sets of reference standards, filters, and Cu strips for MCT systems
3. 12 sets of reference standards for EDS systems assembled into 24 Pelican™ cases
4. 10 each MCT carousel sub-assemblies, which includes the above MCT reference standards assembled therein
5. Chemical analyses and other traceable quality assurance records

References

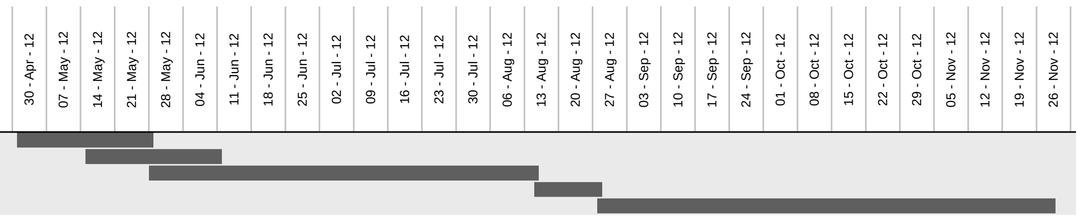
1. J. A. Smith, *Notes on Selecting Reference-Materials and Filters for the EDS CP*, (draft)
2. M. F. DeMicco, *Control of Reference Standards and Materials*, LLNL-AM-475275, March 2011

3. W.D. Brown, J.A. Smith, *TP75-MicroCT Test Bed Data Acquisition for Multi-Energy Zeff and Rho-e Analysis*, v.3, LLNL-TR-615552, January 2013.
4. W. T. White, et. al., MicroCT: *Acquisition of CT Imaging Data for Home Made Explosive Material*, IDD-MCT-SOP-003, LLNL-TM-507819, October 2011.

Appendix A

Draft Gantt chart

Tasks	Start	End	Duration (Days)	% Complete	Working Days	Days Complete	Days Remaining
Task 1: Specify & design reference stds…	5/01/12	5/28/12	28	0%	20	0	28
Task 2: Redesign carousel sub-assy	5/15/12	6/11/12	28	0%	20	0	28
Task 3: Procure, fabricate, assemble	5/28/12	8/15/12	80	0%	58	0	80
Task 4: Inspection, recordkeeping, storage, shipping	8/15/12	8/28/12	14	0%	10	0	14
Task 5: Scan reference standards	8/28/12	11/29/12	94	0%	68	0	94



Appendix B: Data Acquisition for Evaluating Reference Standards, X-ray Source Filters, and Copper-Strip Material

Imaging Reference Standards

1. Calibrate the MicroCT system for the 100-kV and 160-kV spectra per Reference 3.

2. For each Reference Standard, mark the corner at one end; this will provide a “Back-Top” mark for positional reference.

3. Take a 1-slit (160-kV) scan of the Reference Standard, with the “Back-Top” mark upward and directly toward the detector, following the procedures in Reference 4.

4. Radiographing the X-ray Source Filters, Copper-Strip Stock Material, and Radiographic Test Filters for Non-uniformities

Radiographic inspection of the x-ray source filters and copper-strip stock for non-uniformity requires that filters used for the radiography must themselves be free of non-uniformity. Therefor there must be a second piece of the test-object material than can be used as a filter for radiographing the test object. The test-object will first be used as source filter for the radiography, the roles will then be reversed in inspecting the test objects.

Table 2. *kV settings for the Filter/Copper-Strip radiography. The material used for the radiography is identical in composition and thickness to that used for the test objects.*

Test Object Material (and Radiographic Filter Material)	X-ray Source kV
2-mm Al (Filter)	35
1.26-mm Cu (Cu Strip)	115
2-mm Cu (Filter)	145

1. Using a digital x-ray detector array—such as the Thales FlashScan or the Perkin Elmer amorphous-Silicon array—calibrate the MicroCT system for each spectrum, shown in Table 2.

2. For each radiographic filter material, using a piece of the test-object material as source filter, take an x-ray transmission image at the center of the object using the specified spectrum. If the transmission at the center of the image is not between 30% and 40%, reduce or increase the kV until the transmission is about 35%, and repeat Step 1. Record the kV of the selected spectrum.

3. For each radiographic filter and test object:

   a. Position the radiographic filter in the center of the x-ray detector field as shown in Figure 1.

   b. Take a 16-frame average images with the "Corner Mark" up and to the left as shown in Figure 1, and three more rotated clockwise by 90, 180, and 270 degrees respectively from that position.

   c. Repeat for each radiographic filter, then repeat with the role of the radiographic filter and test object reversed. If there are more than one test objects, radiography those following the same procedure.

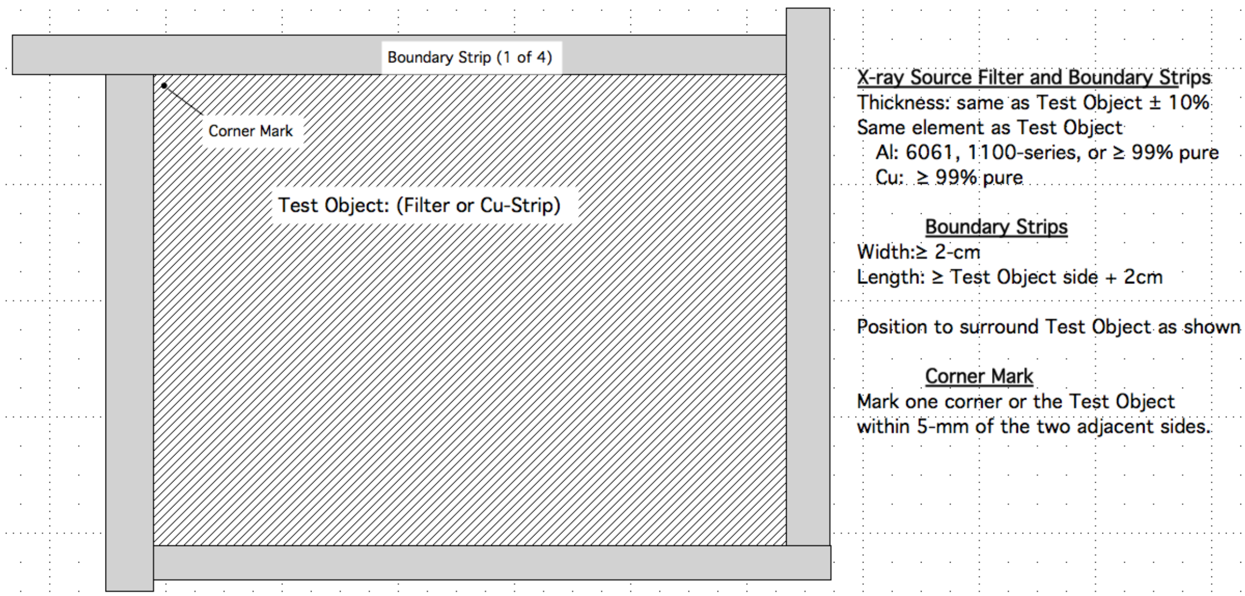


Figure 1. *Each "Test Object" (X-ray source filter, Radiographic filter or Cu-Strip stock material), shall be radiographed on a horizontal surface with a positional "Corner Mark" and with the edges bordered as shown.*