

TP66 – MicroCT Small Volume Comparison

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1. Objectives

The objective of this test plan is to acquire MicroCT water specimen data at different volumes. The data will be analyzed to determine if the x-ray properties are different with respect to volume.

2. Summary of Approach

Three water specimens with different volumes of water will be prepared from the same source using the MicroCT 60 mL nalgene bottles as the container. The three volumes will be 15 mL, 30 mL and 50 mL. The 3 volumes will be scanned in the TAFRL MicroCT system at 160 kV with aluminum and copper filtering (exp1) and at 100 kV with aluminum filtering (exp2).

The MicroCT copper strip analysis, image reconstruction, and reference materials and specimen analysis will be done at TAFRL using LLNL supplied software. TAFRL will ship the data and analysis results to LLNL after completion of all scans. LLNL will review the data after the data is placed on the DHS Image Database (ID). View graphs of the comparison result will be generated and disseminated to the DHS program office and TAFRL.

3. Materials:

- a) 3 Nalgene 60-mL bottles for use with HME specimens for MicroCT scans, Catalog number 2103-0002¹.
- b) Water

4. X-ray Systems:

- a) TAFRL MicroCT System, [Smith]

5. Water Specimen Preparations

Using a common water source, prepare 3-60 mL Nalgene containers with water. Each container will have a different volume of water. The 3 volumes are 15 mL +/- 2 mL, 30 mL +/- 2 mL and 50 mL +/- 2 mL. Mark each container lid with the corresponding volume value.

6. Photographs

Photographs of the 3 water specimens inside and outside the MicroCT system shall be provided with the data.

¹ NALGENE Labware; <http://www.nalgenelabware.com>.

7. MicroCT Procedure for Water Specimens

Place the 15 mL specimen on the TAFRL carousel. Run the 15 mL water specimen in the TAFRL MicroCT system per reference [Klueg1]. For this test plan, only 2 scans will be performed. Both scans of the specimen must occur on the same day. The 2 scans are:

Exp1 - 160kV Al/Cu Filter – 2 slits (**160AlCu**),

Exp2 - 100 kV Al Filter – 2 Slits (**100Al**),

After completion of both scans, download the data to a hard drive and transfer the data to the HMED reconstruction and analysis computer and/or the ABauer computer. The sample will be saved until the data has been reconstructed and the Cu Strip analysis [Kalman1] and the specimen and reference analysis [Kalman2] are completed.

Repeat scanning, analysis and reconstruction for the remaining two volumes (30 mL and 50 mL).

8. Cu Strip QA Check

To verify the x-ray machine is generating a repeatable spectrum, LLNL developed software to monitor the copper strip. The name of the copper strip analysis software is *Cu Strip GUI*. To run the *Cu Strip GUI* refer to the *Cu Strip GUI* manual [Seetho1]. After the software has completed, the resultant values of the mean lower slit and the ratio of the mean upper slit will be recorded in a spreadsheet. The spreadsheet will be sent to LLNL with the data. The Cu Strip QA check is required for HME scans. For this test plan, TAFRL will not rescan if the values are outside the QA bounds.

9. Reconstruction of MicroCT data and Qualitative Review

The MicroCT data will be reconstructed using the LLNL developed software IMGREC [Schneberk]. The reconstructions will be performed on the HMED reconstruction and analysis computer and/or the ABauer computer. Appendix A contains the scripts to execute the reconstruction from IMGREC. The following tasks will be used to reconstruct the Exp1 data:

- a. Place the Exp1 reconstruction file in the same directory as the Exp1 data.
- b. Double click on the IMGREC Icon to start the program.
- c. Using the *Set Current Dir* window, set the directory to the Exp1 data set.
- d. Click *File IO => ReadComFile* and click on the Exp1 script file.
- e. In the *Command File Processing* window, click the *Do-Com-File* button to start the reconstruction.
- f. When the reconstruction is complete the *Current Command* in the *Command File Processing* Window will state “*Reconstructions Complete*”.

Repeat steps a. thru f. for the Exp2 data sets using the Exp2 script file.

After the reconstructions are complete, the data will be qualitatively reviewed to check for centering artifacts or a bad beam hardening correction in Exp2. Review all reconstructed images in each data set. If the data shows horseshoe artifacts, the centering of the data set will be changed, the scripts modified to include the new centering value and the reconstruction re-run with the modified scripts. LLNL will be notified if the scripts change and a copy of the modified scripts will be sent to LLNL. Refer to the

IMGREC manual [Schneberk] to change the centering parameter. For the Exp2 data set, the aluminum reference will be checked for beam hardening correction [Schneberk]. If there is evidence of cupping in the aluminum reference, LLNL should be consulted for correction.

10. MicroCT Reference Analysis

The MicroCT Exp1 and Exp2 data set references will be analyzed using the LLNL developed software *Automated MicroCT Analysis GUI* (AMAG). To run AMAG refer to the AMAG Standard Operating Procedure (SOP) [Seetho2]. After the software has completed, a spreadsheet will be generated. This spreadsheet will be sent to LLNL with the data. The reference analysis check is required for HME scans. For this test plan, TAFRL will not rescan if the values are outside the QA bounds.

11. Data Transfer

All MicroCT photographs, spreadsheets and data will be placed on a hard drive and shipped to LLNL. All directory paths and filenames should *NOT* contain any spaces. Use an underscore “_” symbol for a space. The data shall be filed as follows:

1. MicroCT —
W:\TP66_MicroCT_Small_Volume_Comparison\None\Yxlon\None\
CTDate_Water_Volume\ExpNum

Where:

<i>W:</i>	Is the Windows® drive letter associated with the IDD Working Directory
<i>CTDate</i>	A 6 digit numeral in <i>yymmdd</i> format that provides the date of data acquisition
<i>Volume</i>	Is the specimen volume (15, 30 or 50 mL)
<i>ExpNum</i>	The experiment number (i.e. Exp1 or Exp2)

The photographs shall be filed as follows:

W:\TP66_MicroCT_Small_Volume_Comparison\None\MCT\Photos

The spreadsheets shall be filed as follows:

W:\TP66_MicroCT_Small_Volume_Comparison\None\MCT\Spread

12. References

- Smith Jerel A. Smith, Daniel J. Schneberk, Jeffrey S. Kallman, Harry E. Martz, Jr., David Hoey, *Documentation of the LLNL and Tyndall Micro-Computed-Tomography Systems*, Version 091216, Lawrence Livermore National Laboratory, LLNL-TR-421377, December 17, 2009.
- Kluegl Kluegl, Robert, *Industrial Computed Tomography System Data Collection of Home-Made Explosives*, Version 8, Transportation Security Laboratory, DHS/STD/TSL-XX-XX, August 21, 2009

- Kallman1 Kallman, Jeffrey et al., *MicroCT Copper Strip QA Criteria*, Version 8, Lawrence Livermore National Laboratory, LLNL-PRES-491154, June 16, 2011
- Kallman2 Kallman, Jeffrey et al., *MicroCT Reference Materials QA Window*, Lawrence Livermore National Laboratory, LLNL-PRES-489954, July 11, 2011
- Seetho1 Seetho, Isaac, *MicroCT: X-Ray Radiograph Quality Assurance through the Analysis of Copper Strip Data Using the Matlab CuStrip Analysis GUI*, Lawrence Livermore National Lab, IDD-MCT-SOP-009, December, 2011
- Schneberk Schneberk, D., *Imgrec User Guide: CT Pre-processing, Reconstruction, and Image Processing and Image Inspection Tools*, Version 10, Lawrence Livermore National Laboratory, March 1, 2010
- Seetho2 Seetho, Isaac, *MicroCT: Automated Analysis of CT Reconstructed Data of Home Made Explosive Materials Using the Matlab MicroCT Analysis GUI*, Lawrence Livermore National Lab, IDD-MCT-SOP-007, June 7, 2011

Appendix A – Reconstruction Scripts

! Recon Script for TAFRL Exp 1, 160kV 2-Slits

!

! start with clean signal stack

!

delete 99

!

!

rdset Water

set exstart 455

set eystart 623

set exsize 40

set eysize 8

mkatrad

rdsq atenrad 0

sqext 455 590 1280 270 atenrad

!

rdset atenrad

set nrays 1280

set nslices 270

set rxelements 1280

set ryelements 1280

set rzelements 270

wrsct atenrad

!

rdset atenrad

!

makesino 32 42

set pord 5

set npreord 60

set prthresh 0.003

set rngnorm 0

set rth1 0.03
set ord1 7
set dor1 1
set rth2 0.57
set ord2 21
set dor2 1
!
ringo
Set pxcenter 607.75
cbp
!
rdset atenrad
makesino 228 238
set pord 5
set npreord 60
set prthresh 0.003
set rngnorm 0
set rth1 0.03
set ord1 7
set dor1 1
set rth2 0.57
set ord2 21
set dor2 1
!
ringo
Set pxcenter 607.75
cbp
!
! Reconstruction Complete

! Recon Script for TAFRL Exp2, 100kV 2-Slit

!

! start with clean signal stack

!

delete 99

!

!

rdsct Water

set exstart 455

set eystart 623

set exsize 40

set eysize 8

mkatrad

rdsq atenrad 0

sqext 455 590 1280 270 atenrad

!

rdsct atenrad

set nrays 1280

set nslices 270

set rxelements 1280

set ryelements 1280

set rzelements 270

wrsct atenrad

!

rdsct atenrad

set outlthresh 0.03

outlie

rdsct atenrad

!

makesino 32 42

set pord 5

set npreord 60

set prthresh 0.003
set rngnorm 0
set rth1 0.03
set ord1 7
set dor1 1
set rth2 0.57
set ord2 21
set dor2 1
!
! Set BHC File directory path
!
set bmcfile C:\MicroCT\beam_hardening_info\Hbmc100s-2mmAl-2.txt
set dobm 1
ringo
Set pxcenter 607.75
cbp
!
rdset atenrad
makesino 228 238
set pord 5
set npreord 60
set prthresh 0.003
set rngnorm 0
set rth1 0.03
set ord1 7
set dor1 1
set rth2 0.57
set ord2 21
set dor2 1
!
! Set BHC File directory path
!
set bmcfile C:\MicroCT\beam_hardening_info\Hbmc100s-2mmAl-2.txt

set dobm 1

ringo

Set pxcenter 607.75

cbp

!

! Reconstruction Complete