
Training Outline for the Examination for Gunshot Residue

- 1.0 Purpose** – This document provides an outline for training in the examination for gunshot residue, including the requisite competency testing.
- 2.0 Scope** – This training outline shall be followed by all trainees in the examination of gunshot residue, regardless of experience level.
- 3.0 Prerequisite:** Successful completion of training for SEM/EDX elemental analysis. Reference Trace Unit **Training Outline for SEM/EDX Elemental Analysis.**
- 4.0 Module 1 – Introduction to Gunshot Residue and Primer Residue**
- 4.1 Objectives:** Through completion of this module, the trainee shall have developed and demonstrated the theoretical knowledge and/or practical skills related to:
- 4.1.1** Gunshot residue formation during firearm discharge.
 - 4.1.2** The origin of gunshot residue, the physical make-up of ammunition, chemical composition of primers, and smokeless powders.
 - 4.1.3** The identification and examination of smokeless powders.
- 4.2 Reading Assignments**
- 4.2.1** Schwoeble, A.J. and David L. Exline. *Forensic Gunshot Residue Analysis*. CRC press, 2000.
 - 4.2.2** Saferstein, Richard. *Forensic Science Handbook*, Chapter 11, “Detection of Gunshot Residue: Present Status.” pp. 573-591.
 - 4.2.3** Wallace, J.S. *Chemical Analysis of Firearms, Ammunition, and Gunshot Residue*. CRC press, 2008.
 - 4.2.4** Harrison, R.G. and R. Gilrey. “Firearms Discharge Residues.” *Journal of Forensic Sciences* 4 (1959): 184-199.
 - 4.2.5** Wright, D.M. and M.A. Trimpe. “Summary of the FBI Laboratory’s Gunshot Residue Symposium May 31- June 3, 2005.” *Journal Science Communications* 8.3 (July 2006).
 - 4.2.6** Goleb, J.A. and C.R. Midkiff Jr. “Firearms Discharge Residue Sample Collection Techniques.” *Journal of Forensic Sciences* 20.2 (1975): 701-707.
 - 4.2.7** Rudzitis, E. “Analysis of Results of Gunshot Residue Detection in Casework.” *Journal of Forensic Sciences* 25.4 (1980): 839-846.
 - 4.2.8** Wolten, G.M. and R.S. Nesbitt. “On the Mechanism of Gunshot Residue Particle Formation.” *Journal of Forensic Sciences* 25.3 (1980): 533-545.

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- 4.2.9 Basu, S. “The Formation of Gunshot Residues.” *JFSCA* 27.1 (Jan. 1980).
 - 4.2.10 Bydal, Bruce. “Percussion Primer Mixes.” *AFTE Journal* 22.1 (January 1990).
 - 4.2.11 Lebedzik, Jozef. “GSR Characteristics of Non Toxic and Environment Friendly Ammunitions.” Presentation.
 - 4.2.12 Miyauchi, Hiroshi, et al. “The Contribution of Trace Elements from Smokeless Powder to Post Firing Residues.” *Journal of Forensic Sciences* 43.1 (1998).
 - 4.2.13 Gunaratnam, Lawrence and Kimmo Himberg. “The Identification of Gunshot Residue from Lead – Free Sintox Ammunition.” *Journal of Forensic Sciences* 39.2 (1994).
 - 4.2.14 Schwoeble, A.J. and David Exline. *Current Methods in Forensic Gunshot Residue Analysis*, Chapter 5.
 - 4.2.15 Wallace, Jim S. “Chemical Aspects of Firearms Ammunition.” *AFTE Journal* 22.4 (October 1990).
 - 4.2.16 Wallace, J.S. “Discharge Residue Particles from Blank Cartridges.” *AFTE Journal* 21.2 (April 1989).
 - 4.2.17 Zeichner, Arie, et al. “Antimony Enrichment on the Bullets’ Surfaces and the Possibility of Finding It in Gunshot Residue (GSR) of Ammunition Having Antimony-Free Primers.” *Journal of Forensic Sciences* 43.3 (1998).
 - 4.2.18 Zeichner, Arie, et al. “Gunshot Residue Particles Formed by Using Ammunitions that Have Mercury Fulminate Based Primers.” *JFSCA* 37.4 (Nov. 1992).
 - 4.2.19 Zeichner, Arie, et al. “Gunshot Residue Particles Formed by Using Different Types of Ammunition in the Same Firearms.” *JFSCA* 36.4 (July 1991).
 - 4.2.20 Zeichner, Arie and Nada Levin. “More on the Uniqueness of Gunshot Residue (GSR) Particles.” *Journal of Forensic Sciences* 42.6 (1997).
- 4.3 Exercises:**
- 4.3.1 Perform a new literature search pertaining to gunshot residue and its analysis.
 - 4.3.2 Describe current methods for the analysis of gunshot residue both by bulk and elemental procedures.
 - 4.3.3 Describe the history and theory of gunshot residue detection methods.
 - 4.3.4 Describe capabilities and limitations of analytical instrumentation with respect to gunshot residue.
 - 4.3.5 Identify and confirm the presence of smokeless powder using the following techniques:

- Visual examination
- Stereomicroscopy
- Chemical test (dermal nitrate)
- Micro Fourier Transform Infrared Spectrometry

4.4 Evaluation

- 4.4.1 Perform the dermal nitrate test on five smokeless powders.
- 4.4.2 Analyze five smokeless powders by FT-IR.
- 4.4.3 Record the morphology size, and physical characteristics of a minimum of 10 smokeless powders.
- 4.4.4 Discuss the differences between single, double, and triple based powders.
- 4.4.5 Submit all exercises to trainer for review and discussion.

5.0 Module 2- Analysis of Gunshot Residue Samples using ICP-MS

5.1 **Objectives:** Through completion of this module, the trainee shall have developed and demonstrated the theoretical knowledge and/or practical skills to:

- 5.1.1 Operate and conduct analyses on the inductively coupled plasma mass spectrometer.
- 5.1.2 Demonstrate proper pipette technique.
- 5.1.3 Prepare gunshot residue standards and samples properly.
- 5.1.4 Plot standard curves.
- 5.1.5 Record and interpret results.

5.2 Reading Assignments

- 5.2.1 Saferstein, Richard. *Forensic Science Handbook*, Chapter 11, “Detection of Gunshot Residue: Present Status.” pp. 573-591.
- 5.2.2 Schwoeble, A.J. and David Exline. *Current Methods in Forensic Gunshot Residue Analysis*. c. 2000.
- 5.2.3 ELAN Customer Training optimized for routine ultratrace analysis, PerkinElmerSCIEX.
- 5.2.4 Hill, Steve J. “Inductively Coupled Plasma Spectrometry and its Applications.” 1999.

5.3 Exercises

- 5.3.1 Perform a new literature search pertaining to the theory of inductively coupled plasma mass spectrometry.
- 5.3.2 Practice pipetting water.
- 5.3.3 Practice preparing gunshot residue standards, their digestion, and final dilution for analysis on ICP-MS.
- 5.3.4 Adjust parameters on the ICP-MS and determine the effect of this adjustment.

5.4 Evaluation

- 5.4.1 Successfully complete a practical pipette examination.
- 5.4.2 Successfully complete a practical examination in regards to the operation ICP-MS.
- 5.4.3 Correctly analyze a calibration curve and a set of 10 unknowns provided by the trainer using a properly prepared calibration curve.

6.0 Module 3 - Analysis of Gunshot Residue Samples using SEM/EDX

6.1 **Objectives:** Through completion of this module, the trainee shall have developed and demonstrated the theoretical knowledge and/or practical skills in:

- 6.1.1 The history of gunshot residue detection and the instrumentation used from the 1970s to the present.
- 6.1.2 The distinction between GSR particles and similar environmental particles.
- 6.1.3 Recent changes in ammunition formulations and their effect on particle residue.
- 6.1.4 The morphology and elemental composition of gunshot residue particles.
- 6.1.5 The examination of gunshot residue particles with the SEM/EDX.
- 6.1.6 The interpretation of the data generated by SEM/EDX analysis of gunshot residue.
- 6.1.7 The correlation of data from SEM/EDX analysis with data from bulk analysis of gunshot residue.
- 6.1.8 The significance of particulate analysis and bulk analysis of gunshot residue.

6.2 Reading Assignments

- 6.2.1 ASTM Standard E 1588-95 (Reapproved 2001), “Standard Guide for Gunshot Residue Analysis by Scanning Electron Microscopy/ Energy-Dispersive Spectroscopy.” ASTM International, West Conshohocken, PA, 2001.

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- 6.2.2** “Gunshot Residue Analysis by Scanning Electron Microscopy/Energy-Dispersive X-ray Spectrometry.” ENFSI Working Group Firearms, December 2004.
- 6.2.3** Meng, H.H. and Brian Caddy. “Gunshot Residue Analysis – A Review.” *Journal of Forensic Sciences* 42.4 (1997).
- 6.2.4** Singer, Ronald L., et al. “A Survey of Gunshot Residue Analysis Methods.” *Journal of Forensic Sciences* 41.2 (1996).
- 6.2.5** A.J. Schwoeble and David Exline. Chapter 3, *Current Methods in Forensic Gunshot Residue Analysis*, c. 2000.
- 6.2.6** Harris, Annalivia. “Analysis of Primer Residue from CCI Blazer Lead Free Ammunition by Scanning Electron Microscopy/Energy Dispersive X-Ray.” *Journal of Forensic Sciences* 40.1 (1995).
- 6.2.7** The Aerospace Corporation, *Gunshot Residue Detection*, September 1974, Chapter 7.
- 6.2.8** DeGaetano, Douglas, et al. “A Comparison of Three Techniques Developed for Sampling and Analysis of Gunshot Residue by Scanning Electron Microscopy/Energy Dispersive X-Ray (SEM/EDX).” *Journal of Forensic Sciences* 37.1 (1992).
- 6.2.9** Wrobel, Harald, et al. “Comparison of Properties of Adhesive Tapes, Tabs, and Liquids Used for the Collection of Gunshot Residue and Other Trace Materials for SEM Analysis.” *Journal of Forensic Sciences* 43.1 (1998).
- 6.2.10** Schwartz, Robert H. and Charles Zona. “A Recovery Method for Airborne Gunshot Residue Retained in Human Nasal Mucus.” *Journal of Forensic Sciences* 40.4 (1995).
- 6.2.11** Baru, S., et al. “Fundamental Studies of Gunshot Residue Deposition by Glue Lifts.” *Journal of Forensic Sciences* 42.4 (1997).
- 6.2.12** Wolten, G.M., et al. “Particle Analysis for the Detection of Gunshot Residue I. Scanning Electron Microscopy Dispersive X-Ray Characterization of Hand Deposits from Firing.” *Journal of Forensic Sciences* 24.2 (1979).
- 6.2.13** Andrasko, J. and A.C. Maehly, “Detection of Gunshot Residue on Hands by Scanning Electron Microscopy.” *Journal of Forensic Sciences* 22.2 (1977).
- 6.2.14** Matricardi, V.R. and J. W. Kilty. “Detection of Gunshot Residue Particles from the Hands of a Shooter.” *Journal of Forensic Sciences* 22.4 (1977).
- 6.2.15** Nesbitt, R.S., et al. “Detection of Gunshot Residue by Use of the Scanning Electron Microscope.” *Journal of Forensic Sciences* 21.3 (1976).
- 6.2.16** Lebidzik, Jozef and David Johnson. “Rapid Search and Quantitative Analysis of Gunshot Residue Particles in the SEM.” *Journal of Forensic Sciences* 45.1 (2000).

- 6.2.17** Kee, T. G. and C. Beck. “Casework Assessment of An Automated Scanning Electron Microscope/Microanalysis System for the Detection of Firearms Discharge Particles.” *Journal of Forensic Science Society* 27 (1987).
- 6.2.18** Mosher, P.V., et al. “Gunshot Residue – Similar Particles Produced by Fireworks.” *Canadian Society of Forensic Science Journal* 31.3 (1998).
- 6.2.19** Wolten, G.M., et al. “Particle Analysis for the Detection of Gunshot Residue I: Scanning Electron Microscopy Dispersive X-Ray Characterization of Hand Deposits from Firing.” *Journal of Forensic Sciences* 24.2 (1979)
- 6.2.20** Wolten, G.M., et al. “Particle Analysis for the Detection of Gunshot Residue II: Occupational and Environmental Particles.” *Journal of Forensic Sciences* 24.2 (1979).

6.3 Exercises

- 6.3.1** Perform a new literature search pertaining to the theory of scanning electron microscopy.
- 6.3.2** Describe the peak identification process of elemental analysis with regard to gunshot residue elements.
- 6.3.3** Demonstrate how to archive data from gunshot residue analysis, using both photography of image and storing/printing x-ray spectra.
- 6.3.4** Demonstrate the ability to set up samples for an Automated Gunshot Residue Program.
- 6.3.5** Examine a number of known gunshot residue samples manually and with the automated gunshot residue analysis procedure, become familiar with the morphology, elemental analysis and composition of gunshot residue particles.
- 22 Long Rifle: Federal Remington, and CCI
 - 9mm: Wolf, W-W, Winchester, and PMC
 - 38 Special: CCI Speer, CCI Blazer, PMC, and Remington
 - 44 Magnum: R-P Ammo
- 6.3.6** Examine ten unknown gunshot residue samples.
- 6.3.7** Examine brake pads and fireworks.

6.4 Evaluation

- 6.4.1** Complete all analysis of samples in exercises and turn in all practice exercises with spectra to trainer for discussion and evaluation

7.0 Module 4 – Gunshot Residue Deposition Exercise

7.1 Objectives: Through completion of this module, the trainee shall have developed and demonstrated the theoretical knowledge of factors that can affect the presence and absence of gunshot residue

7.2 Reading Assignments

7.2.1 Schwoeble, A.J. and David Exline. Chapter 3, *Current Methods in Forensic Gunshot Residue Analysis*. c. 2000.

7.2.2 Kilty, J.W. “Activity after Shooting and its Effect on the Retention of Primer Residue.” *Journal of Forensic Sciences* 20.2 (1975).

7.2.3 Matricardi, V.R. and J.W. Kilty. “Detection of Gunshot Residue Particles from the Hands of a Shooter.” *Journal of Forensic Sciences* 22.4 (1977).

7.3 Exercises

7.3.1 Update and compile new literature pertaining to:

- Mechanism by which gunshot residue is deposited on hands by various types of guns.
- Manner in which various firearms operate.
- Effects of ammunition type, caliber, and manufacturer on discharge of gunshot residue.
- Identification of various types of ammunition.
- Effects of weapon type, caliber, and manufacturer on discharge of gunshot residue.
- Effects of time on removal of gunshot residue.
- Contribution of environment and occupation to the presence of elements indicative of gunshot residue.

7.3.2 Caliber Study: The following guns shall be fired a single time using a consistent manner of firing, i.e. single action or double action and one-hand or two-hands. After each weapon is fired, handwipings shall be collected from the shooter’s hands using the standard collection procedure and standard gunshot residue kits. In dealing with semi-automatic weapons include those of straight blow-back and locked breech designs where applicable. The trainee shall be provided with the following types of handguns and long guns with suitable ammunition:

- .22 caliber revolver
- .22 caliber semi-automatic pistol
- .22 caliber single shot rifle
- .22 caliber semi-automatic rifle
- .25 caliber semi-automatic pistol
- .32 caliber revolver
- .32 caliber semi-automatic pistol
- .38 caliber revolver
- .357 magnum revolver

- .45 caliber semi-automatic pistol
- .44 magnum revolver
- .380 caliber semi-automatic pistol
- 9 mm semi-automatic pistol
- .30 caliber semi-automatic rifle
- .30 caliber bolt action rifle
- .30 caliber lever action rifle
- 12 gauge single barrel shotgun
- 12 gauge semi-automatic shotgun

7.3.3 Ammunition Study: Several brands/types of ammunition of different caliber shall be fired. The trainee shall collect the handwipings and analyze them in order to evaluate the results.

- The trainee/shooting designee shall fire several brands of .22 caliber rim fire ammunition in selected weapons, and analyze the swabs in the same manner as above.
- The trainee/shooting designee shall fire several brands of .38 caliber ammunition in selected guns (guns of different manufactures should be selected).
- The trainee shall select a variety of .38 caliber revolvers (large and small frame) and using one brand of ammunition, study the effect that gun size has on the gunshot residue tests

7.3.4 Time Study: A .38 caliber revolver shall be fired on five different occasions, and handwipings collected after zero (0), one (1), two (2), four (4), and six (6) hours respectively. The shooter shall wash his/her hands with water prior to conducting the zero hour hand wiping. The handwipings shall be analyzed and evaluated for the effects that washing hands and time have on the concentration of gunshot residue present.

7.3.5 Number of Shots Fired Study: Selected guns of different caliber shall be fired in a series of multiple rounds (2, 3, 4, 5 and 6) and handwipings collected for evaluation of the multiple firings.

7.3.6 Gun Handling Study: Selected discharged firearms shall be handled, and handwipings shall be collected for analysis and evaluation.

7.3.7 Occupation Study: The trainee shall choose ten (10) people of varying occupations and conduct handwipings by the standard method. These handwipings shall be analyzed and evaluated.

7.4 Evaluation

7.4.1 Prepare and analyze each set of swabbings from the above studies by ICP-MS for barium, antimony, and lead. The data shall be discussed and submitted to the trainer.

8.0 Module 5 – Casework

8.1 Objectives: Through completion of this module, the trainee shall have developed and demonstrated the theoretical knowledge and/or practical skills to:

- 8.1.1 Process gunshot residue kits in regards to proper note taking procedure, evidence handling and marking, and sample selection.
- 8.1.2 Describe the proper techniques for the collection of gunshot residue.
- 8.1.3 Complete a gunshot residue examination from receiving the evidence to writing the Laboratory Report.
- 8.1.4 Demonstrate how to handle, collect, and package gunshot residue evidence.
- 8.1.5 Understand how to recognize and preserve other trace items of potential evidentiary value (e.g., paint, hair, fiber, glass).
- 8.1.6 Demonstrate the proper way to document evidence condition and analytical techniques.
- 8.1.7 Determine probable locations of gunshot residue on inanimate objects (e.g., clothing)
- 8.1.8 Analyze successfully gunshot residue samples by both manual and automated gunshot residue procedures.
- 8.1.9 Write a clear, concise Laboratory Report consistent with Laboratory and Section guidelines. Demonstrate the proper review and interpret results.

8.2 Exercises

- 8.2.1 The trainee shall perform casework with a qualified Forensic Scientist during the course of this training program. The following shall be discussed and practiced with the trainee:
 - 8.2.1.1 Proper procedures for taking notes and marking evidence.
 - 8.2.1.2 Proper procedures for sample selection, the analysis of gunshot residue kits, and collecting adhesive lifts from inanimate objects.
 - 8.2.1.3 Proper packaging for gunshot residue analysis.
 - 8.2.1.4 Selection of the proper analysis techniques to apply in each individual case.
- 8.2.2 Discuss conclusions and report writing as well as the interpretation of gunshot residue evidence and its relevance and weight in conclusions.

8.3 Evaluation

- 8.3.1 Complete a mock case consisting of a minimum of one gunshot residue kit and the collection of lifts from one inanimate object. This exercise will include generating an entire case record and report.

9.0 Module 6 - Final Evaluation and Preparation for Court

- 9.1 **Objectives:** Through completion of this module, the trainee shall have developed and demonstrated the theoretical knowledge and/or practical skills to:

- 9.1.1 Demonstrate courtroom procedures.
- 9.1.2 Present the results of a paint examination in court effectively.
- 9.1.3 Describe the legal and ethical obligations of an expert witness.
- 9.1.4 Describe the admissibility standards set by *Daubert* and *Frye*.

9.2 Reading Assignments

- 9.2.1 CVs or Statements of Qualifications of other Forensic Scientists.
- 9.2.2 *Daubert v. Merrill Dow Pharmaceuticals*, 509 U.S. 579 (1993).
- 9.2.3 *Frye v. United States*, 293 F. 1013 (DC Cir. 1923).
- 9.2.4 Feder, H.A. and M.M. Houck. *Succeeding as an Expert Witness*. 4th ed. Boca Raton: CRC Press, 2008.
- 9.2.5 Kogan, J.D. “On Being a Good Expert Witness in a Criminal Case.” *Journal of Forensic Sciences* 23.1 (1978): 190-200.
- 9.2.6 Philipps, K.A. “The Nuts and Bolts of Testifying as a Forensic Scientist.” *Journal of Forensic Sciences* 22.2 (1977): 457-463.
- 9.2.7 Ron Smith and Associates, Inc. “Courtroom Testimony Techniques: Success Instead of Survival.” Collinsville, Mississippi.
- 9.2.8 Tanton, R.L. “Jury Preconceptions and Their Effect on Expert Scientific Testimony.” *Journal of Forensic Sciences* 24.3 (1979): 681-691.

9.3 Exercises

- 9.3.1 Read literature pertaining to this module.
- 9.3.2 Prepare or update a CV or Statement of Qualifications reflective of experience in gunshot residue examination.
- 9.3.3 Prepare a series of qualifying questions and answers to those questions for use in a voir dire.

9.3.4 Observe pretrial conferences and courtroom testimony of qualified Forensic Scientist, if possible.

9.4 Final Evaluation

9.4.1 Using the mock case, successfully complete a moot court or roundtable discussion.

9.4.2 Successfully complete a final competency test covering all of the training materials.

10.0 Records

- Training file
- Training checklist

11.0 Attachments – N/A

Revision History		
Effective Date	Version Number	Reason
09/17/2012	1	Original ISO Document
10/18/2013	2	Added issuing authority to header
08/29/2014	3	Updated header to Physical Evidence Section – Trace Unit, issuing authority to Physical Evidence Section Forensic Scientist Manager. Updated all references in procedure from Trace Evidence Section to Trace Unit.