



Standard Guide for Reporting of Forensic Primer Gunshot Residue (pGSR) Analysis by Scanning Electron Microscopy/Energy Dispersive X-Ray Spectrometry (SEM/EDS)¹

This standard is issued under the fixed designation E3309; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide describes the contents of a formal, written technical report expressing the results and interpretation of pGSR particle analysis by SEM/EDS by forensic service providers.

1.2 This guide is intended for use by competent forensic science practitioners with the requisite formal education, discipline-specific training (see Practices E2917), and demonstrated proficiency to perform forensic casework.

1.3 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 ASTM Standards:²

E620 Practice for Reporting Opinions of Scientific or Technical Experts

E1732 Terminology Relating to Forensic Science

E1588 Practice for Gunshot Residue Analysis by Scanning Electron Microscopy/Energy Dispersive X-Ray Spectrometry

E2917 Practice for Forensic Science Practitioner Training, Continuing Education, and Professional Development Programs

2.2 Other Documents:

SWGSR Guide for Primer Gunshot Residue Analysis by Scanning Electron Microscopy/Energy Dispersive X-ray Spectrometry³

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

³ Available from Scientific Working Group for Gunshot Residue, <https://www.swggsr.org>.

3. Terminology

3.1 Definitions:

3.1.1 For definitions of terms that can assist in interpreting this standard, refer to Terminology E1732.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *background sample, n*—a recovered sample from a source believed not to have been exposed to pGSR.

3.2.1.1 *Discussion*—Background samples can be used to establish a threshold value.

3.2.2 *candidate particles, n*—particle(s) classified by the instrument software based on detection of appropriate (as specified in Practice E1588) constituent elements as potential pGSR.

3.2.3 *confirmed particles, n*—particle(s) relocated, analyzed, and classified by the analyst as pGSR based on appropriate (as specified in Practice E1588) constituent elements and morphology.

3.2.4 *threshold, n*—a value, based on a background sample study, below which the number of pGSR particles identified cannot be distinguished from background levels and thus cannot be reliably interpreted as associated with the discharge of a firearm or contact with a source of pGSR.

4. Significance and Use

4.1 This guide is designed to be used by forensic service providers when issuing final reports on pGSR analyses by SEM/EDS.

4.2 This guide is intended to be used in conjunction with Practice E1588, Practice E620, and the SWGSR Guide.

5. Report

5.1 The report reflects interpretations based on the classification of particle data from the results of instrumental analysis, and on associated definitions in Practice E1588, the SWGSR Guide, and the scientific literature.

5.2 *Pertinent Information*—Satisfy the requirements of Practice E620, Section 4.7, by listing:

5.2.1 The general examinations conducted, including the generic class and type of instrumentation used and the discipline specific technique, methodology, or procedure performed.

5.2.1.1 *Example Wording*—Exhibit 1 was examined by SEM/EDS for the presence of pGSR particles based on elemental constituents and morphology.

5.2.2 Best practice is to report the quantity of the confirmed pGSR-related particles.

5.2.3 Report the type of particle found using the terms *characteristic*, *consistent*, and *commonly associated* with pGSR. Provide definitions of these terms in the report or in an appendix.

5.2.3.1 The elemental constituents for each particle or particle class can also be included in the report.

5.2.4 If a threshold value is used, state the value in the report.

5.3 *Descriptive Information*—Meet the requirements of Practice E620, Section 4.7, and:

5.3.1 If errors are detected in a report, issue an amended report that contains the reasons for the amendments. Clearly indicate that it is an amended report and include the date of the original report.

5.3.2 If additional work is performed after the original report is issued, issue a supplemental report. Clearly indicate on the supplemental report that it is supplemental and include the date of the original report.

5.3.3 Distribute amended and supplemental reports to all recipients of the original report.

5.4 *Results*—Meet the requirements of Practice E620, Sections 4.8 and 4.9. The example wordings provided below do not purport to show all possible reporting styles and can be subject to style modifications.

5.4.1 *Example wordings based on confirmed particles detected on the recovered sample, either consistent with, or characteristic of pGSR.*

5.4.1.1 (Numerical Value) particles characteristic of pGSR and (numerical value) particles consistent with pGSR were confirmed on the (sample source).

5.4.1.2 (Numerical Value) particles containing lead, barium, and antimony (characteristic) were confirmed on the (sample source).

5.4.1.3 At least (threshold value) particles characteristic of pGSR were confirmed on the (sample source).⁴

5.4.1.4 (Numerical value) particles containing (elemental constituents) were confirmed on the (sample source).

5.4.2 *Example wordings based on the absence of confirmed particles detected on the recovered sample, either consistent with, or characteristic of pGSR.*

5.4.2.1 No (zero) characteristic pGSR particles were detected on the (sample source).

5.4.2.2 No (zero) particles confirmed as either characteristic of or consistent with pGSR were detected on the (sample source).

5.4.2.3 (Numerical value) particles characteristic of pGSR were confirmed but were below the established threshold level to be considered distinguishable from background levels based upon previously conducted background studies.⁴

5.4.2.4 (Sample source) contained only particles that one might expect to see in typical background samples.

5.4.3 *Example wordings for inconclusive or indeterminate results.* For inconclusive or indeterminate results, use wording that clearly indicates to the reader that the analytical data cannot be interpreted unambiguously. This result could be due to factors such as contamination, unusual particle populations, or unusual elements present in particles. Further testing could be warranted (1).⁵

5.4.3.1 The particles on the (sample source) cannot be unambiguously interpreted as pGSR due to _____.

5.4.3.2 The presence of [atypical element(s)] in combination with lead, barium, and antimony is uncommon in characteristic pGSR. Therefore, these particles cannot be unambiguously distinguished as either routine background or pGSR. Submission of additional reference materials (spent cartridge case, weapon, clothing, etc.) for additional testing could result in a more conclusive interpretation.

5.4.3.3 Characteristic pGSR particles were detected on the negative control. This suggests that any pGSR particles found on the sample could have resulted from contamination and therefore no unambiguous interpretation can be made.

5.5 *Interpretations and Limitations*—Meet the requirements of Practice E620, Section 4.8 and 4.9. The examples listed below do not purport to show all possible reporting styles and can be subject to style modifications.

5.5.1 Interpretations can be drawn from the identification of characteristic pGSR particles on a recovered sample from a person. Include wording stating that the identification of characteristic pGSR particles is consistent with the following interpretations: (1) the person discharged a firearm; (2) the person was in the vicinity of a firearm discharge; or (3) the person came in contact with something that had pGSR on it. The number of confirmed particles cannot be used to determine which of these scenarios is more likely.

5.5.1.1 *Example Wording*—The subject could have discharged a firearm, handled a discharged firearm, been in the vicinity of a discharged firearm, or contacted an object with pGSR on it.

5.5.2 Interpretations can be drawn from the identification of pGSR particles on a recovered sample from an inanimate object. Include wording stating that the identification of characteristic pGSR particles on an inanimate object is consistent with, at some time in its history, (1) having contacted a pGSR-related item, (2) having been in the vicinity of a firearm discharge; or (3) having had pGSR transferred to it from a person or another object.

⁴ For use by laboratories with an established threshold value. Laboratories must be able to provide the supporting background sample study and data interpretation which the threshold value is based on, if requested. An Appendix to the report can be used to detail the specific number and classification of particles detected.

⁵ The boldface numbers in parentheses refer to a list of references at the end of this standard.

5.5.2.1 *Example Wording*—(Sample source) contacted a pGSR-related item, was in the vicinity of a firearm discharge, or had pGSR transferred to it.

5.5.3 Interpretations can be drawn from the identification of consistent pGSR particles on a recovered sample from a person. Include wording stating that the identification of consistent pGSR particles is consistent with the following interpretations: (1) the person discharged a firearm; (2) the person was in the vicinity of a firearm discharge; (3) the person came in contact with something that had pGSR on it; or (4) the person came into contact with a non-firearm source of these particles. The number of confirmed particles cannot be used to determine which of these scenarios is more likely.

5.5.3.1 *Example Wording*—Consistent pGSR found on samples recovered from the subject can come from: non-firearm sources, a firearm discharge, handling a firearm, being in the vicinity of a firearm discharge, or coming into contact with an object that has consistent pGSR on it.

5.5.4 Interpretations can be drawn from recovered samples in which pGSR particles are absent. Include wording that states that the results suggest, but do not prove, that either there was no association with the discharge of a firearm, or that the sample source could have been exposed to pGSR, but the pGSR particles were not present when the recovered samples were collected. Do not confuse the absence of pGSR particles with inconclusive interpretations. The absence of pGSR particles supports the theory that an item was not exposed to pGSR.

5.5.4.1 *Example Wording*—There is no indication that the (sample source) has any association with the discharge of a firearm. However, the absence of pGSR particles does not prove that a person did not discharge a firearm. It is possible that the (sample source) did discharge a firearm, but that pGSR particles were not deposited, were removed by activity, or were not detected.

5.5.4.2 *Example Wording*—There is no indication that the (sample source) came into contact with pGSR or was in the vicinity of a firearm during discharge. If (sample source) was, then the pGSR was not deposited, not detected, or removed.

5.5.5 No interpretations can be drawn from an analysis with inconclusive results.

5.5.5.1 *Example Wording*—No determination can be made from the (sample source) for the following reason(s) _____. Submission of additional evidence could yield conclusive findings.

5.5.6 No interpretations can be drawn from the identification of particles that are commonly associated with pGSR. This includes lead, barium, or antimony particles found in isolation in the absence of characteristic and consistent pGSR particles. Do not report the confirmation of such particles as potentially having originated from the discharge of a firearm, except possibly in the case of the following:

5.5.6.1 Interpretations can be drawn from the identification of particles commonly associated with pGSR when high levels of small spherical lead particles that are known to be found in bullet or pellet debris, or from a primer comprised of a lead-based compound only, are supported by analysis of a

control reference sample. Clearly state that these particles could also be from a non-firearm source.

5.5.7 When comparing results to a known ammunition, include the details of the elements and combinations of elements that are being considered in the interpretation. Indicate these particle types could originate from other ammunitions, unless the ammunition in this case is manufactured for a unique application, such as ammunition with taggant elements.

5.5.8 Attach an explanatory statement or page to help the reader understand any distinctive circumstances associated with the investigation. Examples of explanatory statements are:

5.5.8.1 Consistent particles are known to be associated with pGSR. More information regarding their possible origin could be provided if the known firearm or ammunition is submitted for further testing.

5.5.8.2 Particles of pGSR can be present on victims of a gunshot-related injury.

5.5.8.3 Published studies have shown that residue from certain fireworks, brake pads, or airbag detonators can contain pGSR-like particles; however, there are typically elemental indicators that exclude these particles from being identified as pGSR (2-6).

5.5.8.4 Law enforcement officers, active duty military personnel, hunters, or firearm enthusiasts can be a source of pGSR.

5.5.8.5 Transfers of pGSR particles from secondary and tertiary sources are possible. However, there is currently insufficient data in the literature to estimate the frequency of these occurrences.

5.5.8.6 In general, the elemental constituents and morphology are not sufficiently distinctive to allow using pGSR evidence to identify a specific firearm or ammunition; however, there are exceptions, such as ammunition containing taggants (see SWGGSR).

5.6 *Remarks/Additional Information*—Include remarks or additional information in the report. Specific references for a topic are listed in the References and Related Material sections at the end of this guide.

5.6.1 There is no established error rate for pGSR analysis by SEM/EDS.

5.6.2 Limitations and sources contributing to uncertainty of measurement in pGSR. Statement(s) related to factors affecting uncertainty in the number of pGSR particles identified on the sample and limitations can be listed in the report. Some of these factors are:

5.6.2.1 *Primary Transfer Considerations*—Factors that can influence the number of particles identified:

(1) Formation factors including, but not limited to, effects based on type of firearm, physical condition of firearm, caliber of firearm, and type of ammunition (7-13).

(2) Deposition factors including, but not limited to, effects based on number of rounds fired, proximity to discharging firearm, physical barrier preventing deposition of PGSR (for example, gloves, hands in pockets, etc.), and environmental conditions (for example, wind, rain, etc.) (12, 14-23).

(3) Retention factors including, but not limited to, washing/wiping of hands, excessive perspiration, blood on hands,

activity of subject, elapsed time from discharge to collection, and environmental conditions (wind, rain, etc.) (**12, 19, 23, 24 and 25**).

(4) Collection factors including, but not limited to, condition of sampling surface being tested, and competence of the collection personnel (**26 and 27**).

(5) Analysis factors including, but not limited to, sampling plan, limit of detection, instrument performance, and presence of interfering materials on the adhesive surface of the sampling device that obscure pGSR.

5.6.2.2 *Secondary Transfer Considerations*—Factors that can influence the number of particles transferred (**1, 28-33**):

(1) Being in physical contact with an individual who has recently discharged a firearm.

(2) Being in physical contact with an inanimate object that has pGSR on it.

(3) Wearing an item of clothing that has pGSR on it.

5.6.2.3 *Tertiary Transfer Considerations*—Factors that can influence the number of particles transferred from secondary sources (**33, 34**):

(1) Being in physical contact with an inanimate surface that has secondary pGSR on it.

(2) Being in physical contact with an individual who has secondary pGSR on them.

6. Keywords

6.1 energy dispersive X-ray spectrometry; forensics; particle analyses; primer gunshot residue; service providers; scanning electron microscopy; technical reports

APPENDIXES

(Nonmandatory Information)

X1. THE GSR SPECIFIC PORTION OF THE REPORT: EXAMPLE 1

X1.1 Samples

Item 5 One (1) primer residue kit from John Smith
Item 7 One (1) primer residue kit from Jane Doe

X1.2 Methods

X1.2.1 Items 5 and 7 were examined using a scanning electron microscope with an energy dispersive X-ray spectrometer (SEM-EDS) for the presence of primer gunshot residue (pGSR) based on the elemental constituents and morphology of particles sampled from the item.

X1.3 Results and Interpretations

X1.3.1 Particles characteristic of primer residue are those that have a non-crystalline appearance and contain all three elements: lead, barium and antimony. Particles with these characteristics are strongly associated with the discharge of a firearm and are rarely found in particles from any other source.

X1.3.2 Particles consistent with primer residue have the same appearance and typically include two of the three elements listed above. This type of particle is often associated with the discharge of a firearm but can also come from numerous non-firearm sources.

X1.3.3 *Item 5:*

X1.3.3.1 Nine (9) particles characteristic of primer residue and one (1) particle consistent with primer residue were found in the area examined on the sample in Item 5 marked *right hand*. Six (6) particles characteristic of primer residue and three (3) particles consistent with primer residue were found in the area examined on the sample in Item 5 marked *left hand*. It should be noted that, as in accordance with laboratory standard practice, no more than 10 particles are confirmed per sample during a routine examination.

X1.3.3.2 The pGSR particles on Item 5 could have been deposited when (1) the person discharged a firearm; (2) the person was in the vicinity of a firearm discharge; or (3) the person came in contact with something that had pGSR on it. The number of confirmed particles cannot be used to determine which of these scenarios is more likely.

X1.3.4 *Item 7:*

X1.3.4.1 No pGSR particles were found in the areas examined on the samples in Item 7 marked *right hand* or *left hand*.

X1.3.4.2 Item 7 provides no indication that Jane Doe has an association with the discharge of a firearm. However, the absence of pGSR particles does not prove that a person did not discharge a firearm. It is possible that Jane Doe did discharge a firearm but that pGSR particles were not deposited, were removed by activity, or were not detected.