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Standard Practice for Interpretation and Report Writing in Forensic Comparison of Trace Materials



Draft Document

Standard Practice for Interpretation and Report Writing in Forensic Comparisons of Trace Materials

1. Scope

In trace evidence comparisons, the forensic examiner analyzes the evidence and resulting data, forms an opinion, and summarizes the findings in a written report. The examiner shall also interpret and report the overall meaning of those findings. A three-step process can be used in forming the opinion. Step one involves a binary decision to determine whether the compared samples can be discriminated based on the comparison of the observed/measured data. Step two is the evaluation of the results on a source level to determine and explain the significance of finding any differences or lack of differences between the samples being compared (i.e., how discriminating and rare the material's characteristics are). Finally, step three is the evaluation of these results on an activity level to determine and explain the relevance of the findings under given circumstances (i.e., evaluation of the evidence considering competing propositions of alleged activities, and factors such as transfer mechanisms and persistence). These steps can be conducted sequentially or simultaneously, depending on the methods used for the description and evaluation of the data.

This practice describes the information that shall be included in trace evidence written reports regarding steps two and three of the process: interpretation of the overall results of comparative examinations. Such information includes a qualitative or quantitative means of assessing the meaning of an association (i.e., an inability-to-discriminate result) in terms of the source of the trace material. This practice focuses primarily on the second step of interpretation at the source level. When activity level information is available, this information can be incorporated into the interpretation of the third step and then be included in the report.

This practice aims: a) to provide guidance to forensic examiners to standardize the interpretation of comparative examinations of trace evidence and b) to describe those items that shall be included in the report to aid the reader in interpreting the reported results. This practice is primarily focused on the interpretation and writing of comparative reports and is not intended to provide a specific format for writing a report. It focuses primarily on fibers, glass, hairs, paint and tape but can be applied to other trace materials. A review article by Trejos/Koch/Mehltretter is pending and provides a thorough bibliography that also serves as the body of work supporting the approach presented throughout this practice.

This practice uses a qualitative approach to communicate the significance of an association or exclusion, based on a) the foundational validity of the scientific methods used for the comparison of the items; b) discrimination capabilities of the analytical protocol, and c) existing knowledge of how discriminating the compared characteristics are based on survey studies, reference collections, or databases. If error rates and formal statistical methods are available to provide a quantitative approach (e.g., likelihood ratio, Bayesian framework), they can be used to supplement the qualitative approach described in this practice.

2. Referenced Documents

2.1 ASTM Standards:

E620 Standard Practice for Reporting Opinions of Scientific or Technical Experts

E678 Standard Practice for Evaluation of Scientific or Technical Data

E860 Standard Practice for Examining and Preparing Items That Are Or May Become Involved in Criminal or Civil Litigation

E1732 Standard Terminology Relating to Forensic Science

2.2 ISO/IEC 17025 General Requirements for the Competence of Testing and Calibration Laboratories

3. Terminology

Activity level interpretation: The evaluation of the evidence in comparative examinations that aims to explain its condition (e.g., pulled hair versus shed hair), presence in a particular location (e.g., glass found embedded in the sole of a shoe versus glass found on a shirt) or in a given quantity (e.g., multiple fragments versus single fragment) and therefore considers factors such as transfer mechanisms and persistence.

Association: The conclusion arising when there is more support for the proposition that two items originated from the same source as opposed to the proposition they originated from different sources.

Class characteristic(s): Physical, optical, or chemical properties that establish membership in a class, category, or group. Class characteristics are general characteristics that define a category of items or objects, but are not alone sufficient to define individuality.

Comparative report: A written report that is generated when two or more items are compared in order to determine whether the items could have originated from the same or different sources. For purposes of this practice, a comparative report shall include an assessment of the significance of the comparative results.

Consistent: In comparative examinations, when data or observations of a questioned sample fall within the range of the known sample or there are no exclusionary or reproducible differences between the items. In other words, two samples cannot be differentiated based on their properties as observed or measured by a particular technique, examination, or analytical scheme. Also *Indistinguishable*.

Cross-transfer: The two-way exchange of materials between objects that can occur when they come into contact with one another.

Data: All qualitative and quantitative information, whether documentary, physical, observed, measured, or collected.

Exclusionary difference(s): A difference in a feature or property between compared items that is substantial enough to conclude that they did not originate from the same source.

Note 1: An exclusionary difference is statistically supported when an appropriate statistical analysis shows a result outside the range of what usually occurs when the items originate from the same source.

Note 2: When a statistical analysis is not suitable, an exclusionary difference may be determined by expert judgment.

Indistinguishable: See *Consistent*.

Investigative lead report: A written report that provides useful information about possible sources of a questioned item, in the absence of a known comparison sample.

Population: The totality of items or units of material under consideration.

Qualitative data: Data from characteristics and descriptors that cannot be easily measured, but can be described, classified or categorized (e.g., color, textures, shape of a spectral peak).

Quantitative data: Data that can be measured and described with numbers (e.g., dimensions such as height, width, and length; features such as refractive index; concentration of a component).

Relevant population: The pool of potential alternative sources. If the examiner considers the relevant population to be narrower than all possible sources, the examiner should disclose what population is considered relevant.

Significance: The weight/meaning of the evidence or conclusion.

Source level interpretation: The evaluation of the evidence in comparative examinations that considers whether the items could have originated from the same or different sources. For example, the glass fragments originated from the broken window versus the fragments originated from another source of broken glass.

Trace material: Physical evidence that can result from the transfer of generally small quantities of materials (e.g., fibers, glass, hairs, paint, tape).

4. Comparative Report Contents

4.1 Reports that contain only raw analytical data (e.g., refractive-index data) or results without an explanation of their meaning are inadequate as such reports could lead to a misunderstanding of the results and inappropriate conclusions being drawn by the reader of the report.

4.2 The following information shall be included in the body of the report regarding interpretation of the overall results of comparative examinations: a listing of analytical techniques, results, and conclusions

and opinions, including an assessment of the significance of the results and the uncertainty in this assessment.

5. Significance Assessment

5.1 It is the responsibility of the examiner to use only relevant data in the evaluation of the evidence.

5.2 An assessment of the significance of the results and conclusions shall be recorded in the report.

5.2.1 When associations are made, conclusions such as “consistent with” or “could have come from” are not sufficient conclusions on their own. The significance of the association shall be communicated clearly and qualified properly in the report.

5.2.2 Conclusions and opinions shall also include a basis for the reported significance. The basis should include factors that limit or increase the significance of the association or lack thereof.

5.3 Conclusions and opinions shall be based on all of the available relevant data acquired and developed, as well as accepted scientific principles, experience, and training.

5.4 A thorough description of the significance or limitation of the conclusion and opinion shall be discussed in detail.

5.4.1 The significance shall be portrayed through an interpretation scale, placed into the report in its entirety to provide context for a specific conclusion. In addition to determining a conclusion type, the basis for the determination shall be detailed in the written report.

The following interpretation scale is an example for use in comparative examinations. Every type of conclusion may not be applicable in every case or for every material type. This does not preclude a laboratory from tailoring the concept to meet its needs (refer to Sections 6 through 10 of this document for additional guidance):

Physical Fit – *Physical Fit* is the highest degree of association between items. It is the conclusion that the observations provide the strongest support for the proposition that the items originated from the same source as opposed to the proposition they originated from different sources. *Physical Fit* is reached when the items that have been broken, torn, or separated exhibit physical features that correspond/re-align in a manner that is not expected to be replicated.

Associations of Evidence with Class Characteristics:

Class characteristics are physical, optical, or chemical properties that establish membership in a class, category, or group. Associations of evidence based on class characteristics do not establish that the items came from the same source. Class associations can have varying degrees of significance. In general, the smaller the size of the group relative to the relevant population, the more significant the association. These types of associations are categorized as follows:

Association with Highly Discriminating Characteristics – An association in which items could not be differentiated based on the examinations conducted. Therefore, the possibility that the items came from the same source cannot be eliminated. Additionally, the items share unusual characteristics that would rarely or never be expected to occur in the relevant population. This provides very strong to extremely strong support for the proposition that the items originated from the same source as opposed to the proposition they originated from different sources. This is the highest degree of association that can be determined in the absence of a *Physical Fit*.

Association with Discriminating Characteristics – An association in which items could not be differentiated based on the examinations conducted. Therefore, the possibility that the items came from the same source cannot be eliminated. Other items have been manufactured or could occur in nature that would also be indistinguishable from the submitted items and could be encountered in the relevant population. This provides moderately strong to strong support for the proposition that the items originated from the same source as opposed to the proposition they originated from different sources. The analytical techniques used in the analysis of these items can provide high levels of discrimination among natural and manufactured materials and therefore this is considered a high degree of association.

Association with Limitations – An association in which items could not be differentiated based on the examinations conducted. Therefore, the possibility that the items came from the same source cannot be eliminated. This provides slight to moderate support for the proposition that the items originated from the same source as opposed to the proposition they originated from different sources. As compared to the categories above, this type of association has decreased evidential value. For example, the items are more commonly encountered in the relevant population, a complete analysis was not performed due to limited characteristics or a limited analytical scheme, or minor variations were observed in the data. Minor variations could be due to factors such as known contamination of the sample(s) or having a sample of insufficient size to adequately assess heterogeneity of the entity from which it was derived.

Inconclusive – No conclusion could be reached regarding an association or an exclusion between the items.

Exclusion with Limitations – The item exhibits differences from the comparison sample that support that it did not originate from the source, as represented by the comparison sample. This provides stronger support for the proposition that the items did not originate from the same source as opposed to the proposition they originated from the same source. An *Exclusion/Elimination* conclusion was not reached due to limiting factors, such as possible variability in the source.

Exclusion/Elimination – The items exhibit differences that support a conclusion that the two items did not originate from the same source.

5.4.2 The presence of cross-transfers or multiple transfers are examples of factors that could increase the significance of findings. When there are multiple transfers or cross-transfers, a conclusion should be reached separately for each individual transfer. A statement regarding the opined significance of the combined individual transfers can be included.

5.5 In some areas of trace evidence it is possible to use a statistical approach (e.g., frequency of occurrence, likelihood ratios) to establish an association and to evaluate its significance. If sufficient scientific data exist for a statement of significance, the provenance of these data shall be provided either in the body of the report or included as an appendix to the report. If a database is used for this purpose, the use and limitations of the database shall also be included or made available. Further details on the application of statistics are beyond the scope of this document.

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6. Fiber Reporting

6.1 Textile fibers are transferred either by direct (primary) transfer or indirect (secondary) transfer. The possibility of transfer depends on the types of fabric or surface involved in the contact and the nature and duration of the contact. Contact with a textile can result in both passive and forceful transfers.

6.1.1 Forensic fiber analysis is typically a comparison of two or more fibers, usually from a questioned source and a known source for the purpose of determining if the known source can be eliminated or included as a potential donor of the questioned fiber(s). Forensic fiber analysis may also involve the comparison of two or more questioned fibers to determine if they could share a common source.

6.1.2 Fiber examinations can include the identification of the fiber type or end-use possibilities to provide investigative information when a known source is not provided/available for comparison.

6.2 Analytical methodologies used for fiber analysis have a direct impact on significance assessments. Fiber comparisons commonly consist of determining if a questioned fiber(s) is consistent in physical, optical, and chemical properties with fiber(s) comprising part or all of a known sample. Textiles can only be associated to a single source when there is a physical fit of textile products along damaged, torn, or cut edges.

A Physical Fit conclusion is the examiner's opinion that the possibility is negligible that the compared textile materials originate from different damaged sources. A Physical Fit conclusion is not currently based upon statistically-derived measurements; it is also not based upon exhaustive comparisons to all potential sources.

6.2.1 A comprehensive analytical scheme for natural and manufactured fibers starts with a visual and microscopical examination to compare physical and optical characteristics such as shape, diameter, color, surface features, presence/absence of inclusions or delustrants, fluorescence, and birefringence. Instrumental analysis is used to further examine/compare color [e.g., microspectrophotometry (MSP)]. In the case of manufactured fibers, additional techniques (e.g., FTIR) are used to examine/compare chemical composition.

6.2.2 If the analytical scheme is not inclusive of the assessment of the physical and optical characteristics, instrumental analysis of color and analysis of chemical composition when applicable, then a statement of decreased significance is warranted.

6.2.3 Increased or decreased significance can be based on available information for the relevant population (e.g., published discrimination studies, product manufacturing and distribution information).

6.3 Source factors that could increase the significance of an association

6.3.1 Physical fit

6.3.2 Unusual physical or optical properties (e.g., variegated coloring, electrostatic core, fading, discoloration)

6.3.3 Corresponding surface contamination or damage

6.3.4 Unusual fiber type (e.g., aramid), depending on the scenario

6.3.5 Conditions that limit the possible sources of the fibers (e.g., fibers found in a vehicle with a limited number of passengers wearing known garments)

6.4 Source factors that could decrease the significance of an association

6.4.1 Limited number of relevant analytical techniques used in the comparison

6.4.2 Commonly observed fiber type, such as white cotton or blue denim cotton

6.4.3 Limited number of features available for comparison

6.4.4 Limited sample size

6.4.5 Condition of samples (e.g., degraded samples)

6.4.6 Minor physical or chemical differences between items being compared that could be a result of sample heterogeneity, contamination of the sample(s), or having a sample of insufficient size to adequately assess the homogeneity of the item from which it was derived

6.4.7 Circumstances that increase the possibility of a random association (e.g., known sample is a uniform)

6.5 Example Scenarios for Each Type of Conclusion

The following examples are provided to assist in reaching each type of conclusion. The examples provided are not meant to be binding or all-inclusive.

6.5.1 Physical Fit

6.5.1.1 This type of conclusion can be reached for fibers only when there is a physical fit of a textile piece with another textile along its torn/cut/damaged edge, or through corresponding individual characteristics (e.g., surface features that carry across the pieces).

6.5.2 Association with Highly Discriminating Characteristics

6.5.2.1 Post-manufacturing mark on the items (e.g., both known and questioned items exhibit similar damage, staining, craft paint on surface)

6.5.2.2 Questioned to known association in which an unusual combination of characteristics, such as damage and color alteration, is present on both items

6.5.3 Association with Discriminating Characteristics

6.5.3.1 Questioned to known association in which a typical analysis scheme was performed (e.g., questioned nylon fiber corresponding to a known carpet)

6.5.4 Association with Limitations

6.5.4.1 Ubiquitous fibers (e.g., white cotton, blue denim cotton)

6.5.4.2 Limited characteristics to differentiate the fiber type, depending on scenario (e.g., undyed natural fiber, colorless polyester on a tape lift of a vehicle seat compared to a white cotton/polyester t-shirt)

6.5.4.3 Reduced analytical scheme due to lack of characteristics of the fiber or lack of available equipment

6.5.4.4 Limited amount of material for a comprehensive characterization

6.5.5 Inconclusive

6.5.5.1 The questioned fiber is too damaged to determine fiber type or original color.

6.5.5.2 The questioned fiber is not suitable to do most examinations.

6.5.5.3 The questioned fiber is dissimilar in color to the known but might be faded/stained (uncertain if an actual difference).

6.5.6 Exclusion with Limitations

6.5.6.1 The Exclusion with Limitations conclusion is not usually applicable for fiber comparisons.

6.5.7 Exclusion/Elimination

6.5.7.1 Exclusionary differences in physical, optical, or chemical properties between the compared fibers

6.6 Example Wording for Types of Conclusions

These are only examples. Each laboratory determines the specific wording to be used in its reports. In addition to text similar to below (or similar to the examples throughout this document), the specific techniques used shall also be included as part of the report.

6.6.1 Physical Fit

6.6.1.1 "The torn edge of the questioned fabric piece physically fits and aligns with the torn edges of the known shirt fabric, providing extremely strong support for the proposition that the items originated from the same source of torn material as opposed to the proposition they originated from different torn sources. **(Physical Fit).**"

6.6.1.2 "The torn edge of the questioned rope/cordage piece physically fits and aligns with the torn edges of the known rope/cordage, providing extremely strong support for the proposition that the items originated from the same source of torn material as opposed to the proposition they originated from different torn sources. **(Physical Fit).**"

6.6.2 Association with Highly Discriminating Characteristics

6.6.2.1 "Questioned fibers found on the victim's shirt were compared to the known blanket utilizing (*insert methods here*). A singed, purple polyester questioned fiber found on the victim's shirt corresponds in (*insert characteristics here*) to the singed fibers that comprise the known purple blanket. Therefore, the questioned fiber either originated from the known blanket or from another textile with the same manufactured and acquired characteristics (**Association with Highly Discriminating Characteristics**). This type of conclusion was reached because no differences were observed between the fiber and because of the damage to both items.

6.6.2.2 "Questioned rope/cordage found on the victim's wrists was compared to the known rope/cordage utilizing (*insert methods here*). The questioned rope/cordage corresponds in (*insert characteristics here*) to the known rope/cordage, and both items contain extensive fraying. Therefore, the questioned rope/cordage either originated from the known rope/cordage or from another source of cordage with the same acquired characteristics (**Association with Highly Discriminating Characteristics**). This type of conclusion was reached because no differences were observed between the ropes/cordage and because of the damage observed on both items.

6.6.3 Association with Discriminating Characteristics

6.6.3.1 "Questioned fibers found on the suspect's shoes were compared to fibers comprising the known carpet utilizing (*insert methods here*). Brown nylon fibers found on the suspect's shoes correspond in (*insert characteristics here*) to the brown nylon fibers that comprise the known carpet. Therefore, the questioned fibers either originated from the known carpet or from another textile with the same characteristics (**Association with Discriminating Characteristics**). This type of conclusion was reached because other carpets (or textiles) containing fibers made to the same specifications (type, color, microscopic characteristics, etc.) would also be indistinguishable from these fibers. The techniques utilized in this comparative analysis can readily distinguish different fibers."

6.6.3.2 "Questioned yarns/rope/cordage found on the suspect were compared to the known rope/cordage utilizing (*insert methods here*). Brown nylon yarns found on the suspect correspond in (*insert characteristics here*) to the brown nylon yarns that comprise the known rope/cordage. Therefore, the questioned yarns/rope/cordage either originated from the known rope/cordage or from another source of cordage with the same characteristics (**Association with Discriminating Characteristics**). This type of conclusion was reached because other cordage containing yarns made to the same specifications (type, color, microscopic characteristics, etc.) would also be indistinguishable from these yarns. The techniques utilized in this comparative analysis can readily distinguish different yarns."

6.6.4 Association with Limitations

6.6.4.1 "Questioned fibers found on the vehicle tape lifts were compared to fibers comprising the known shirt utilizing (*insert methods here*). Round, colorless polyester fibers found on the tape lifts correspond in (*insert characteristics here*) to the round, colorless polyester fibers that comprise the known shirt. Therefore, the questioned fibers either originated from the known shirt or from another textile with the same characteristics (**Association with Limitations**). This type of conclusion was reached because of the limited number of distinguishing characteristics available for comparison between the known and the questioned fibers as well as the prevalence of this fiber type."

6.6.4.2 "Questioned yarns/rope/cordage found on the vehicle tape lifts were compared to the known rope/cordage utilizing (*insert methods here*). Round, colorless polyester yarns found on the tape lifts correspond in (*insert characteristics here*) to the round, colorless polyester yarns that comprise the known rope/cordage. Therefore, the questioned yarns either originated from the known rope/cordage or from another source of cordage with the same characteristics (**Association with Limitations**). This type of conclusion was reached because of the limited number of distinguishing characteristics available for comparison between the known and the questioned yarns."

6.6.5 Inconclusive

6.6.5.1 "Questioned fibers collected from the victim's hair were compared to fibers comprising the known carpet of the suspect's vehicle using (*insert methods here*). The red nylon fibers from the victim's hair correspond in (*insert characteristics here*) to the red nylon carpet fibers from the vehicle. However, slight differences were noted in the (*insert characteristics here*) of the questioned fibers in

comparison to the known carpet. Because of the exposure of the questioned fibers to the environment (based on case information/ communication from agency), no conclusion can be reached as to whether the red fibers from the victim's hair originated from the vehicle carpet or from another source of red fibers (**Inconclusive**)."

6.6.5.2 "Questioned yarns collected from the victim's hair were compared to the known rope/cordage from the suspect's vehicle using (insert methods here). The red nylon yarns from the victim's hair correspond in (insert characteristics here) to the red nylon yarns composing the rope/cordage collected from the vehicle. However, slight differences were noted in the color and fluorescence of the questioned yarns in comparison to the known rope/cordage. Because of the exposure of the questioned yarns to the environment, no conclusion can be reached as to whether the red yarns from the victim's hair originated from the rope/cordage from the vehicle or from another source of red yarns (**Inconclusive**)."

6.6.6 Exclusion/Elimination

6.6.6.1 "Questioned fibers from the scene were compared to fibers comprising the jacket using (*insert methods here*). The red nylon fibers recovered from the broken window are different in color and fiber type to the blue polyester fibers from which the jacket was manufactured. Therefore, the questioned fibers did not originate from the jacket (**Exclusion/Elimination**)."

6.6.6.2 "Questioned yarns/rope/cordage from the scene were compared to the known rope/cordage using (insert methods here). The nylon yarns recovered from the broken window are different in color and fiber type to the polyester yarns that comprise the rope/cordage. Therefore, the questioned yarns/rope/cordage did not originate from the known cordage (**Exclusion/Elimination**)."

6.7 Other Considerations

6.7.1 Standard methods of analysis (e.g., ASTM) shall be used when they are available. Other technology can be employed if it has been reported in peer-reviewed sources and has been validated according to ISO/IEC 17025.

6.7.2 The exact location where fibers are found can affect the significance of a particular fiber association as related to activity level interpretation; in other words, the location of fibers on different areas of the body or on specific items at the scene can influence the significance of that association. It is important to be aware, however, that fibers can move within packaging/during transport of evidence.

6.7.3 Ubiquitous Fibers. While certain fiber types are commonly found in the environment (e.g., white cotton, blue denim cotton), case circumstances should be considered to determine if the fibers should be analyzed.

6.7.3.1 Example report wording. "Although the fibers were blue denim cotton, which are commonly found in the environment, finding blue denim cotton fibers that are embedded in the damaged area of the vehicle lends more significance to their probative value."

6.7.4 Transfer and persistence. It is important that the fiber examiner is aware of the factors that influence the transfer and persistence of fibers in order to evaluate the significance of the findings within a specific set of circumstances.

6.7.4.1 The number of questioned fibers associated with a known source is important in estimating actual contact. The greater the number of fibers, the more likely that direct and potentially recent contact occurred between fiber sources. The converse is not necessarily true, however, and even one fiber association can have probative value. Additionally, finding no fibers does not de facto mean that no contact occurred. Each case is different, and the examiner should consider all of the relevant factors before determining the significance of the evidence.

6.7.4.2 The type of physical contact between two sources influences the number of fibers transferred and the value placed on their discovery. Physical contact of an extended duration or of a forceful nature can result in many fiber transfers. Brief contact is less likely to transfer multiple fibers.

6.7.4.3 Fabric construction affects the number and types of fibers that could transfer. For example, tightly woven or knitted fabrics shed fewer fibers than loosely knit or woven fabrics. Fabrics composed of filament fibers shed less than fabrics composed of staple fibers.

6.7.4.4 The condition and wear of the fabric also affects the degree of fiber transfers. Newer fabrics can have an abundance of loosely adhering fibers on the surface of the fabric. Well-worn fabrics typically do not have loosely adhering surface fibers, but can have damaged areas that easily shed fibers. Damage to a fabric caused during physical contact increases the possibility of fiber transfer.

6.7.4.5 Transferred fibers are lost at an exponential rate, depending on the types of fabrics involved and on the movement of the clothing after contact. For example, the clothing of an immobile victim can retain transferred fibers for a longer period of time than someone who is actively moving. It is impossible to predict precisely how many fibers might remain on the clothing of a living individual after a given period, but it is important for investigators to retrieve and protect clothing as soon as possible.

6.7.4.6 Background information regarding the sources involved (e.g., textiles, individuals) and any possible prior contact between them can affect the significance of the association.

6.7.5 Activity factors that could increase the overall assessment of the significance

6.7.5.1 Large number of fibers transferred.

6.7.5.2 Location where the fibers are found (e.g., under fingernail)

6.7.5.3 A piece of fabric, yarn, or mass of fibers transferred from a source

6.7.5.4 Cross-transfer of fibers between two sources

6.7.5.5 Fiber fusions (e.g., fiber embedded in or on a vehicle during an impact)

6.7.6 Activity factors that could decrease the overall assessment of the significance

6.7.6.1 Reasonable explanation as to why there was a transfer of fiber(s) (e.g., two individuals known to be in close or frequent contact)

6.7.7 Examples of additional wording of information related to activity level

6.7.7.1 “The large number of fibers recovered from Item 1 indicates a direct contact occurred with a textile.”

6.7.7.2 “The fibers embedded in the damaged area of the suspect vehicle indicates that the vehicle has been in forceful contact with a fabric-clad item.”

6.7.8 If many different fibers are associated between known and questioned sources (e.g., two or more articles of clothing had fibers transfer from them, one shirt had two different fiber types transfer to it, fibers from multiple sources in a location transferred to a victim), then the possibility that contact occurred between these items could be increased. Cross-transfers reduce the chance that the fibers were all deposited by coincidence.

6.7.8.1 When two or more associations are being reported, each association should be reported separately. Additional text can then be included describing whether and how the multiple reported associations could affect the overall significance assessment and conclusions arising from the totality of the examination results.

6.7.8.2 Example report wording (cross-transfer). “The presence of numerous fibers on the victim’s shirt that could not be distinguished from the fibers comprising the known shirt from the subject and the presence of numerous fibers on the subject’s shirt that could not be distinguished from the fibers comprising the known shirt from the victim provides stronger support for contact having occurred between the two shirts than either transfer alone.”

6.7.8.3 Example report wording (multiple transfers). “The presence of fibers on the victim's shirt that could not be distinguished from the fibers comprising both the known shirt and the known pants from the subject provides stronger support for contact having occurred from the subject's shirt and pants to the victim’s shirt than either transfer alone.”

7. Glass Reporting

7.1 The breaking of glass generates small fragments that can be transferred to a person or to other objects in the vicinity of the breaking glass. Glass evidence can provide information about when the transfer of the glass happened since the transfer would have to take place after the glass was broken. For example, in a hit and run scenario, glass fragments that are transferred from a broken windshield onto the driver's clothing could provide information about who was inside the vehicle when the glass was broken.

7.1.1 Forensic glass analysis is typically a comparison of two or more glass fragments to determine if they can be discriminated using their physical, optical or chemical properties. If the samples are distinguishable in any of these observed and measured properties, it is concluded that they do not originate from the same broken glass object represented by the submitted known sample. If the samples are indistinguishable in all of these observed and measured properties, the possibility that they originated from the same broken glass object cannot be eliminated.

7.1.2 Glass examinations can include the identification of the glass type or end use to provide investigative information about the broken source and the breaking activity. For example, a common end-use question is whether the questioned fragment of broken glass could have originated from sheet glass, container glass or a decorative glass. End-use questions can arise more frequently on crime scene reconstruction or investigative cases where no known source is available.

7.2 Analytical methodologies used for glass comparisons have a direct impact on significance assessments. Glass examinations commonly consist of comparing the physical, optical, and elemental composition of known and questioned glass fragments. Broken glass found as trace evidence usually exhibits class characteristics. It is important to note, however, that although there could be several objects with identical properties, glass fragments can originate only from broken and not intact objects. Glass can only provide Physical Fit conclusions when there is a physical fit of two glass fragments along their broken edges.

A Physical Fit conclusion is the examiner's opinion that the possibility is negligible that the compared glass fragments originate from different broken glass sources. A Physical Fit conclusion is not currently based upon statistically-derived measurements; it is also not based upon exhaustive comparisons to all potential sources.

7.2.1 A typical analytical scheme, unless sample size or condition prohibits it, shall include visual and microscopical examinations and characterization of the glass by its optical properties and elemental composition.

7.2.2 Increased or decreased significance may be stated based on the techniques used for the examination and respective discrimination capabilities, and on frequency of occurrence or random match probabilities from glass populations.

7.2.2.1 Analytical sensitivity and precision of the methods used for elemental analysis, along with the observed variations within and between samples in the relevant population, allow for high discrimination between different sources. The use of Inductively Coupled Plasma-Mass Spectrometry

(ICP-MS), micro-X-Ray Fluorescence Spectroscopy (uXRF), or Laser Ablation-ICP-MS (LA-ICP-MS) is recommended for elemental analysis and comparison of glass when sufficient sample is available.

Due to the ability of these sensitive elemental techniques to differentiate glass manufactured in different plants, use of one of these techniques is required in order to report a potential association of increased significance. Since there are many plants producing glass over many years, coincidental indistinguishable elemental composition can exist but are not frequent. Random match rates around 0.1% have been observed in different sample sets.

7.2.2.2 In reporting a potential association, a statement of decreased significance shall be reported if the analytical scheme does not include elemental analysis at all or if the elemental analysis is conducted by less sensitive methods such as scanning electron microscopy – energy dispersive x-ray spectroscopy (SEM-EDS). The sensitivity of SEM-EDS is not suitable to detect those trace elements known to differentiate glass fragments, but SEM-EDS can detect differences between glasses based on major and in some instances minor elemental concentrations. SEM-EDS analysis of glass can be conducted to characterize sources (i.e., float vs. container vs. leaded glass) or for comparative analysis when the small size of the sample prevents the analysis by more discriminating methods.

7.3 Source factors that could increase the significance of an association

7.3.1 Physical fit (fracture fit)

7.3.2 Unusual physical features, such as unusual weathering markings, labeling (or partial labeling) of Department of Transportation (DOT) numbers or manufacturer markings (e.g., headlamp).

7.3.3 Glass with a known limited population or rare characteristics (e.g., glass with unusual RI, custom made glass, glass with coatings, ultra-clear low Fe glass, sheet glass with unusually high concentrations of elements such as Er, Mo, Ce, Se).

7.3.4 Thermal history of the sample (if the compared glass fragments were both exposed to the same environmental temperature conditions, e.g., fire or explosion).

7.4 Source factors that could decrease the significance of an association

7.4.1 Analytical scheme does not include an assessment of both the optical and trace elemental composition of the glass.

7.4.2 Condition of samples (e.g., small sample size).

7.4.3 Thermal history of the sample (if the compared glass fragments were exposed to different environmental temperature conditions, e.g., fire). This could affect the optical properties prior to annealing but not the elemental profile.

7.4.4 Particular properties that are not very discriminating, such as a relatively common RI.

7.5 Example Scenarios for Each Type of Conclusion

The following examples are provided to assist in reaching each type of conclusion. The examples provided are not meant to be binding or all-inclusive.

7.5.1 Physical Fit

7.5.1.1 This type of association can be reached for glasses only when there is a physical fit (fracture fit) of two or more pieces of broken glass or through corresponding individual characteristics (e.g., surface features such as number, letter or a patterned label) that carry across the pieces.

7.5.2 Association with Highly Discriminating Characteristics

7.5.2.1 Association of glass fragments characterized by elemental analysis using ICP-based methods alone, or ICP-based methods in combination with physical or optical measurements (RI).

7.5.2.2 Association of glass fragments characterized by RI and elemental analysis using μ XRF when elements with atomic number equal or higher than 37 (Rb) are present above the limit of quantitation.

7.5.2.3. Association of glass fragments for which the estimated random match probability of the measured properties is very small (e.g., smaller than 0.2%).

7.5.2.4. Association of glass fragments for which the estimated calibrated likelihood ratios (LR) provide strong support to the same-source hypothesis over the different-source hypothesis (e.g., LR greater than 500).

7.5.3 Association with Discriminating Characteristics

7.5.3.1 Association of glass fragments characterized by elemental analysis using μ XRF alone, when elements with atomic number equal or higher than 37 (Rb) are present above the limit of quantitation.

7.5.3.2 Association of glass fragments characterized by elemental analysis using RI and μ XRF, when elements with atomic number equal or higher than 37 (Rb) are below the limit of quantitation.

7.5.3.3. Association of glass fragments for which the estimated random match probability of the measured properties is small (e.g., between 0.2% and 2%).

7.5.3.4. Association of glass fragments for which the estimated calibrated likelihood ratios provide moderate support to the same-source hypothesis over the different-source hypothesis (e.g., LR between 50 and 500).

7.5.4 Association with Limitations

7.5.4.1 Reduced analytical schemes (e.g., only RI or RI and elemental analysis by SEM EDS).

7.5.4.2 Limited sample or sample condition that prevents adequate characterization.

7.5.4.3. Association of glass fragments for which the estimated random match probability of the measured properties is relatively high (e.g., greater than 2%).

7.5.4.4. Association of glass fragments for which the estimated calibrated likelihood ratios provide weak support to the same-source hypothesis over the different-source hypothesis (e.g., LR between 1 and 50).

7.5.5 Inconclusive

7.5.5.1 The questioned glass is insufficient to do most examinations (e.g., physical/optical examinations can identify as glass but sample is too small for other comparison methods).

7.5.6 Exclusion with Limitations

7.5.6.1 The Exclusion with Limitations conclusion is not usually applicable for glass comparisons.

7.5.7 Exclusion/Elimination

7.5.7.1 Physical, chemical, or optically exclusionary differences between the compared glasses.

7.6 Example Wording for Types of Conclusions

These are only examples. Each laboratory determines the specific wording to be used in its reports. In addition to text similar to below (or similar to the examples throughout this document), the specific techniques used shall also be included as part of the report.

7.6.1 Physical Fit

7.6.1.1 “A physical/fracture fit was identified/observed based on corresponding random characteristics on the broken edges of the Item 1 piece of glass and the broken edges of Item 2, the known source. Therefore, this correspondence provides extremely strong support for the proposition that they were once part of the same broken glass object and extremely weak support for the proposition that the glass came from different broken glass objects (**Physical Fit**).”

7.6.2 Association with Highly Discriminating Characteristics

7.6.2.1 “The Item 1 known glass fragments and the Item 2 questioned glass fragment are colorless glass (*specify color when possible*) that show characteristics of tempered glass (*specify glass type when possible, e.g., flat, float, container glass*). Comparison of Items 1 and 2 by visual and microscopical techniques, refractive index and elemental analysis by (*specify sensitive technique here*) determined that they could not be differentiated based on their physical and optical characteristics or their elemental composition. These combined methods have shown to be highly discriminating between glass sources. Therefore, the questioned glass originated from the windshield (*specify the known source, e.g., sheet of glass, window, windshield*) as represented by the known sample or another source of broken glass indistinguishable in the measured properties (**Association with Highly Discriminating Characteristics**). This type of conclusion was reached because coincidental associations of glass originating from different sources could occur but are expected to be highly unusual.”

7.6.3 Association with Discriminating Characteristics

7.6.3.1 “All glass fragments received as Item 1 (known) and the glass fragment received as Item 2 (questioned) are colorless glass (*specify color when possible*) that show characteristics of tempered glass (*specify glass type when possible e.g., flat, float, container glass, etc.*). Comparison of Items 1 and 2 by

visual and microscopical techniques, refractive index and elemental composition by (*specify sensitive technique here*) determined that they could not be differentiated based on their physical and optical characteristics and their elemental composition. These combined methods have shown to be discriminating between glass sources. Therefore, the questioned glass originated from the windshield (*specify the known source, e.g., sheet of glass, window, windshield*) submitted as a known sample or another source of broken glass indistinguishable in the measured properties (**Association with Discriminating Characteristics**). This type of conclusion was reached because coincidental associations of glass originating from different sources could occur but are expected to be unusual.”

7.6.4 Association with Limitations

7.6.4.1 “The glass fragment received as Item 1 (questioned glass) and the glass fragments received as Item 2 (known) are indistinguishable in their refractive indices. Therefore, the questioned glass originated from the known window or another source of glass with same refractive index. (**Association with Limitations**). This type of conclusion was reached due to the limited number of characteristics available for comparison between the known and questioned sample. In glass specimens where only refractive index data can be measured, the chance of finding coincidental associations are significantly higher. More discriminating techniques could not be applied as a result of the limited size of the questioned sample.”

7.6.4.2 “The glass fragment received as Item 1 (questioned glass) and the glass fragments received as Item 2 (known) are indistinguishable by refractive index and elemental analysis with SEM-EDS. Therefore, the questioned glass originated from the known window or another source of glass with the same refractive index and elemental composition (**Association with Limitations**). This type of conclusion was reached due to the limited number of characteristics available for comparison between the known and questioned sample. In glass specimens where only refractive index and SEM-EDS data can be measured, the chance of finding coincidental associations are significantly higher. SEM-EDS is limited to the detection of major and minor elements but not suitable for detection of trace elements. More discriminating techniques could not be applied as a result of the limited size of the questioned sample.”

7.6.5 Inconclusive

7.6.5.1 “Although there are some similarities between the Item 1 questioned glass and the Item 2 container, the fragment size of Item 1 does not allow for the complete comparison of optical or chemical properties. Therefore, no conclusion can be reached (**Inconclusive**).”

7.6.5.2 “Although there are some similarities between Item 1 and Item 2, the quantity of glass fragments received as the Item 2 known sample is insufficient to completely characterize the optical and elemental composition of the known broken source. Therefore, no conclusion can be reached (**Inconclusive**).”

7.6.6 Exclusion/Elimination

7.6.6.1 “The Item 1 glass fragment differs in physical and optical properties from the Item 2 windshield, and therefore the known glass source represented as Item 2 is not the source of Item 1 (**Exclusion/Elimination**).”

7.6.6.2 “The Item 1 glass fragment differs in physical, optical, and chemical properties from the Item 2 bottle, and therefore Item 2 is not the source of Item 1 (**Exclusion/Elimination**).”

7.6.6.3 “The Item 1 glass fragment differs in elemental composition from the Item 2 window, and therefore Item 2 is not the source of Item 1 (**Exclusion/Elimination**).”

7.7 Other considerations

7.7.1 Standard methods of analysis (e.g., ASTM) shall be used when they are available. Other technology can be employed if it has been reported in peer-reviewed sources and has been validated according to ISO/IEC 17025.

7.7.2 Glass examinations generate quantitative data (RI and elemental composition) that allow the application of statistical methods to make decisions about differences or similarities between samples. The laboratory or examiner shall select a criterion that is appropriate to the analytical method used to generate the data and that has acceptable/known error rates.

7.7.2.1 The use of databases (when available) to evaluate the rarity of measured features or to estimate a frequency of random match or a likelihood ratio (LR) can provide an objective measure of significance and is therefore recommended. Databases developed and validated in forensic laboratories or reported in the peer-reviewed literature can be used to estimate a quantitative measure of the significance through frequency of random match or LR estimations to describe the value of the glass evidence.

7.7.3 Transfer and persistence. It is important that the glass examiner is aware of the factors that influence the transfer and persistence of glass in order to evaluate the significance of the findings in a specific set of circumstances.

7.7.3.1 The value of evidence can be enhanced by the cross-transfer of evidence between victim and suspect, cross-transfer between objects or the transfer of multiple items of evidence. In instances in which two or more associations are being reported, each association should be reported separately. Additional text can be included describing whether and how the multiple reported associations can affect the overall significance assessment and conclusions arising from the totality of the examination results.

7.7.3.2 The understanding of the phenomena of transfer and persistence of glass fragments is fundamental for the interpretation and assessment of the significance of the evidence. The scientific literature related to transfer and persistence of glass spans more than five decades.

7.7.3.3 The number and size of fragments transferred and retained in the recipient is related to several factors such as type of clothes and garments, distance from the breaking window, wet versus dry clothing, type and thickness of glass, the breaking force, the number of blows, and the object that broke the window. Glass fragments are more likely to transfer to wet clothing than to dry clothing; garments such as sweaters and socks retain more fragments than pants; glass is more commonly found on footwear than on clothing of the general population; the number of fragments transferred decreases exponentially with increased distance from the source; the rate of decrease of fragments versus distance is even more pronounced for fragments larger than 1mm.

7.7.4 Activity factors that could increase the overall assessment of the significance

7.7.4.1 Large number of fragments transferred from a single source

7.7.4.2 Large number and size of fragments transferred and retained on the recipient (see 7.7.3.3)

7.7.4.3 Location where the glass is found (e.g., upper surface of the shoe versus embedded in the sole of the shoe)

7.7.5 Activity factors that could decrease the overall assessment of the significance

7.7.5.1 Location where the glass is found (e.g., embedded in the sole of the shoe versus on the upper surface of the shoe)

7.7.5.2 Inability to determine the location of fragments on a searched surface (e.g., fragments recovered in the evidence container or garment improperly wrapped)

7.7.6 Examples of additional wording of information related to activity level

7.7.6.1 “The large number of glass fragments recovered from item 1 indicates a recent exposure to broken glass.”

7.7.6.2 “It is rare to find broken glass fragments in the head hair of persons not involved in glass-breaking activities.”

8. Hair Reporting

8.1 Hair can be shed from people and animals. Hairs can also be forcibly removed. Hairs that have been shed or forcibly removed could then be transferred between two people, a person and a location, or a person and an object. If questioned hairs are recovered, they can be used to establish an association between a person or animal to a location, to another person, or to an object with which he/she/it has had contact.

8.1.1 Forensic hair analysis can consist of three parts: the classification via microscopical examination of questioned hairs (e.g., somatic origin, ancestry), the microscopical comparison of questioned hairs to known hairs, and the assessment of hair suitability for DNA analysis to provide additional information about the source of the questioned hairs.

8.1.2 Certain situations require qualifying statements in the report. Some example situations include:

8.1.2.1 A microscopical comparison of a questioned hair to hairs representative of a known source is conducted for the purpose of determining if the known source is a potential donor of the questioned hair. Microscopical hair comparisons are not a means of personal identification.

8.1.2.2 When reporting similarities found by a microscopical analysis of hairs, the author shall properly qualify conclusions and indicate that DNA results can differ in the source of the potential donor. Further discussion of DNA analysis of hairs is beyond the scope of this document.

8.1.2.3 Classifications of ancestry are based on macroscopic and microscopic characteristics that are typically observed in hairs from individuals of a given ancestral group. These classifications do not necessarily correspond to an individual's outward appearance or self-identification of ancestry.

8.1.3 Unlike many manufactured products, hair from a single source is not homogeneous in its physical and microscopic characteristics. Within the hairs from a single source, there is a range of physical and microscopic characteristics that can be present. A person can also have atypical hairs that have different physical or microscopic characteristics from the majority of the hairs from the same somatic area. A microscopical comparison should be performed with a representative known sample consisting of a sufficient number of hairs that includes the full range of variation in length, form and color. In addition, the known sample should be collected from the entire somatic area in question and as close to the time of the incident as practical. If a known hair sample does not represent the range of physical and microscopic hair characteristics present within the hairs from a single source, or a significant amount of time has elapsed between the incident and known sample collection, a microscopical comparison could result in a false exclusion.

8.1.4 While there is a range of physical and microscopic characteristics within the hairs from a single source, that range of characteristics could also overlap the range of characteristics within the hairs from another source. The overlap in characteristics between hairs from different sources means that a questioned hair might not be able to be differentiated from multiple sources.

8.2 A comprehensive analytical scheme shall include visual and microscopical examination and comparison using a comparison microscope to assess and compare physical characteristics.

8.2.1 The physical and microscopic characteristics present in a hair have a direct impact on significance assessments.

8.3 Source factors that could increase the significance of an association

8.3.1 Dyed hair that has grown out so it shows the natural color and the dyed color

8.3.2 Hair that has been dyed different, distinctive colors several times

8.3.3 Disease, hereditary hair conditions, or unusual characteristics (e.g., head hairs with a double medulla, hairs exhibiting characteristics from external causes)

8.3.4 Conditions that limit the possible sources of the hair (e.g., numerous hairs embedded in the interior surface of a broken windshield of a motor vehicle with known passengers)

8.4 Source factors that could decrease the significance of an association

8.4.1 Limited number of characteristics present for comparison

8.4.2 Very short hair

8.4.3 Very light natural color

8.4.4 Colorless hair (no pigmentation)

8.4.5 Bleached hair

8.4.6 Opaque hair (microscopic characteristics not visible)

8.5 Example Scenarios for Each Type of Conclusion

The following examples are provided to assist in reaching each type of conclusion. The examples provided are not meant to be binding or all-inclusive.

8.5.1 Physical Fit

8.5.1.1 A physical fit is not possible with hair comparisons. Additionally, an identification cannot be made based on the examination and comparison of the microscopic characteristics of hair.

8.5.2 Association with Highly Discriminating Characteristics

8.5.2.1 Behavioral factors and styling [e.g., a hair has been dyed several, distinctive colors multiple times and each color change is still visible (at least on a microscopic level)]

8.5.2.2 Disease or hereditary condition that is manifest in hair

8.5.2.3 External environmental factors (e.g., putrefied root, insect activity, burnt hairs)

8.5.3 Association with Discriminating Characteristics

8.5.3.1 A hair with a range of physical and microscopic characteristics that are included in the representative known sample. This can include microscopic color variation that reflects natural environmental exposures and conditions over time.

8.5.4 Association with Limitations

8.5.4.1 A hair possesses a limited number of physical and microscopic characteristics

8.5.4.2 A hair that is very short can possess a limited number of physical and microscopic characteristics and might not exhibit as much variation in width, cross-sectional shape, or color along its length in contrast to a long hair.

8.5.4.3 A hair that naturally or through artificial means has very little or no pigmentation could possess fewer characteristics on which to base an association.

8.5.4.4 A hair that is heavily pigmented, or has been heavily dyed so that the hair appears opaque, results in a comparison that is based upon a very limited number of characteristics.

8.5.5 Inconclusive

8.5.5.1 A questioned hair possesses similar characteristics to the known sample but also exhibits some differences. It cannot be determined whether these differences can be attributed to a time differential between the date of the incident and the collection date of the known sample, post-depositional changes, the standard not being truly representative, or because the questioned hair is from a different source.

8.5.6 Exclusion with Limitations

8.5.6.1 The questioned and known hairs possess different characteristics (e.g., cross-section, thickness variation, color, distribution of pigment). Due to the range of characteristics possible within an individual, an Exclusion/Elimination conclusion is not possible.

8.5.7 Exclusion/Elimination

8.5.7.1 The questioned and known hairs are grossly different in their macroscopic/microscopic characteristics (e.g., standard consists of over 50 tightly curled dark brown head hairs 3-5 inches long, the questioned hair is a straight blonde head hair 18 inches long).

8.6 Example Wording for Types of Conclusions

These are only examples. Each laboratory determines the specific wording to be used in its reports. In addition to text similar to below (or similar to the examples throughout this document), the specific techniques used shall also be included as part of the report.

The following statement or an equivalent statement shall be included in every report of a microscopical hair comparison that results in an association: "Microscopical hair comparisons are not a means of personal identification. The number of individuals that could be included as a possible source is unknown." An additional statement can be added such as: "These results should be evaluated in conjunction with DNA analysis."

8.6.1 Physical Fit: not applicable

8.6.2 Association with Highly Discriminating Characteristics

8.6.2.1 “Based on a visual and microscopical comparison, the characteristics observed in the Item 1 questioned hair fall within the range of characteristics in the Item 2 known hairs. Items 1 and 2 also possess distinctive characteristics that are indicative of (*insert characteristic here, e.g., behavioral, disease/hereditary, or environmental characteristic*) that is not typically or routinely observed in human hairs. Therefore, the source of Item 2 (person A) is included as a potential source of Item 2 (**Association with Highly Discriminating Characteristics**). Microscopical hair comparisons are not a means of personal identification. The number of individuals that could be included as a possible source is unknown. These results should be evaluated in conjunction with DNA analysis.”

8.6.3 Association with Discriminating Characteristics

8.6.3.1 “Based on a visual and microscopical comparison, the characteristics observed in the Item 1 questioned hair fall within the range of characteristics in the Item 2 known hairs. Therefore, the source of Item 2 (person A) is included as a potential source of Item 1 (**Association with Discriminating Characteristics**). Microscopical hair comparisons are not a means of personal identification. The number of individuals that could be included as a possible source is unknown. These results should be evaluated in conjunction with DNA analysis.”

8.6.4 Association with Limitations

8.6.4.1 “Based on a visual examination and microscopical comparison, the characteristics observed in the Item 1 questioned hair fall within the range of characteristics in the Item 2 known hairs; however, the characteristics for comparison are limited. Therefore, the source of Item 2 (person A) cannot be eliminated as a potential source of Item 1 (**Association with Limitations**). The absence of a full range of physical and microscopic characteristics (*insert limitation, e.g., hair too short, too little or no pigmentation, hair appears opaque, no root structure present*) precludes a more definitive comparison result. Microscopical hair comparisons are not a means of personal identification. The number of individuals that could be included as a possible source is unknown. These results should be evaluated in conjunction with DNA analysis.”

8.6.5 Inconclusive

8.6.5.1 “Based on a visual and microscopical comparison between the Item 1 questioned hair and the Item 2 submitted known hairs, some similarities and some dissimilarities in the physical and microscopic characteristics were observed. Therefore, no conclusion can be reached as to whether or not the source of Item 2 (person A) can be included as a potential source of Item 1 (**Inconclusive**). The comparison was limited due to (*list limiting factors if applicable*).”

8.6.6 Exclusion with Limitations

8.6.6.1 “Based on a visual and microscopical comparison between the Item 1 questioned hair and the Item 2 submitted known hairs, dissimilarities in the physical and microscopic characteristics were observed. Based on the known sample submitted, Item 1 is not consistent with originating from the

source of the Item 2 known hairs (**Exclusion with Limitations**). Assuming the known hair sample is representative, this indicates that the hairs did not originate from the same source. Due to the natural variation that occurs in hairs as a biological specimen, and the effect that time and environment can have upon a hair sample, these observed differences are insufficient for a definitive exclusion/elimination.”

8.6.7 Exclusion/Elimination

8.6.7.1 “Based on a visual and microscopical comparison between the Item 1 questioned hair and the Item 2 submitted known hairs, gross dissimilarities in the physical and microscopic characteristics (e.g., characteristics of ancestry) were observed. Therefore, the source of Item 2 (person A) can be excluded as a potential source of Item 1 based on the submitted sample (**Exclusion/Elimination**).”

8.7 Other considerations

8.7.1 Standard methods of analysis (e.g., ASTM) shall be used when they are available. Other technology can be employed if it has been reported in peer-reviewed sources and has been validated according to ISO/IEC 17025.

8.7.2 When a questioned hair is found to fall within the range of physical and microscopic characteristics of two or more known hair samples, a statement shall be added to the report that both sources of the known hair samples (persons A and B) can be included as possible sources of the questioned hair.

8.7.3 In instances in which two or more associations are being reported (e.g., head and pubic hair), each association should be reported separately. Additional text can then be included describing whether and how the multiple reported associations could affect the overall significance assessment and conclusions arising from the totality of the examination results.

8.7.3.1 Example report wording. “The presence of hairs on the victim’s shirt similar to the known hairs from the subject and the presence of hairs on the subject’s shirt similar to the known hair from the victim provides stronger support for contact having occurred between the victim and subject than either transfer alone.”

8.7.4 When there is a cross-transfer of hairs and each transfer individually results in an association, a statement regarding the significance of the cross-transfer can be reported separately.

8.7.4.1 Example report wording. “The presence of hairs on the victim’s shirt similar to the known hairs from the subject and the presence of hairs on the subject’s shirt similar to the known hair from the victim provides stronger support for contact having occurred between the victim and subject than either transfer alone.”

8.7.5 Transfer and persistence. It is important that the hair examiner be aware of the factors that influence the transfer and persistence of hair in order to evaluate the findings in a specific set of circumstances to assess the appropriate significance of the findings.

8.7.5.1 The presence of hairs with anagen roots (hairs in the active growing phase) could indicate the forceful removal of the hairs, while the presence of hairs with telogen roots (hairs in the resting phase that could have been naturally shed) could be less meaningful.

8.7.5.2 The retention of transferred hairs can depend upon the activity of the recipient object (e.g., person's clothing, furniture) after the transfer. For example, hair on the clothing of a person who is moving around can be lost (fall off or transferred to another object) over time, while hair on a chair can remain there for a long period of time or could be transferred to the clothing of another person who sat on the chair subsequent to the original deposition of the hair.

8.7.6 Activity factors that could increase the overall assessment of the significance

8.7.6.1 Large number of hairs transferred from a single source

8.7.6.2 A clump of hairs transferred from a single source

8.7.6.3 Cross-transfer of hairs between two people

8.7.7 Activity factors that could decrease the overall assessment of the significance

8.7.7.1 The recipient works in a hair salon and is exposed on a regular basis to hairs with a wide variety of physical characteristics, hairs that could be forcefully removed, hairs that could have been naturally shed, and cut hair fragments.

8.7.7.2 Reasonable explanation for a transfer of hair(s) (e.g., two individuals living together)

8.7.8 Example of additional wording of information related to activity level

8.7.8.1 "A clump of similar hairs with stretched roots and adhering tissue/root sheath are indicative of having been forcibly removed."

8.7.8.2 "Due to cohabitation of the involved individuals, a transfer of hair between these individuals would not be uncommon."

9. Paint Reporting

9.1 Contact with a painted surface can result in transfers. The appearance and morphology of the transfer can indicate whether the paint was deposited while wet, during passive contact (e.g., an item coming into contact with loose or flaking paint particles), or as the result of forcible contact (e.g., abraded or smeared paint due to a motor vehicle striking a pedestrian or another vehicle).

9.1.1 Forensic paint analysis is typically a comparison of two or more paints, usually from a questioned source and a known source for the purpose of determining if the known source can be eliminated as a potential donor of the questioned paint.

9.1.2 Paint examinations can also include the identification of the paint type or end use. For automotive paints this can include attempts to determine manufacturer, model, model year, and color information.

9.2 Analytical methodologies used for paint comparisons and discrimination studies have a direct impact on significance assessments. Paint can only provide Physical Fit conclusions in the case where there is a physical fitting of two paint fragments along the broken edges, with a substrate where it was previously in contact, or through surface scratches and features that carry across onto the questioned chip from the remaining finish.

A Physical Fit conclusion is the examiner's opinion that the possibility is negligible that the compared paint chips originate from different damaged paint sources. A Physical Fit conclusion is not currently based upon statistically-derived measurements; it is also not based upon exhaustive comparisons to all potential sources.

9.2.1 A comprehensive analytical scheme, unless sample size or condition prohibits it, shall include visual and microscopical examinations to assess physical characteristics and instrumental analysis to compare the organic and inorganic components of the paint layers.

9.2.2 When reporting an association between samples that do not have a complex layer structure, a statement of decreased significance should be reported if the typical analytical scheme cannot be completed to assess all of the physical and chemical characteristics that are routinely evaluated for samples of a given paint type (e.g., limitations of the sample size or condition, absence of equipment routinely used).

9.2.3 Increased or decreased significance is based on available information for the relevant population (e.g., published discrimination studies, product manufacturing and distribution information, databases).

9.3 Source factors that could increase the significance of an association

9.3.1 Physical fit (fracture fit)

9.3.2 Unusual physical or chemical features (e.g., surface contamination or damage)

9.3.3 Paint formulation applied for other than its intended use (e.g., architectural paint applied to a vehicle)

9.3.4 Paint with a known limited population (e.g., customized finishes)

9.3.5 Increased number of layers

9.3.6 Unusual layer sequence where sequence order is typically controlled/mandated/deliberate

9.3.7 For automotive paint, the following source factors could increase the significance of an association.

9.3.7.1 Repair during manufacture [original equipment manufacturer (OEM) repair]

9.3.7.2 Aftermarket refinish– number of layers and characteristics of the refinish affect association significance

9.3.7.3 Non-automotive paint layer within a layer system

9.3.7.4 Refinish layer(s) that change the topcoat color of the vehicle

9.3.8 For architectural paint, the following source factors could increase the significance of an association.

9.3.8.1 Multiple layers of various colors

9.3.8.2 Presence of inclusions, contaminants, or soil

9.3.8.3 Spray paint layer within a layer system

9.4 Source factors that could decrease the significance of an association

9.4.1 Limited number of analytical techniques used in the comparison

9.4.2 Limited number of features available for comparison

9.4.3 Condition of samples (e.g., mixed smears, contamination throughout the transferred material, minute sample amount)

9.4.4 Minor physical or chemical differences between items being compared that could be a result of sample heterogeneity, contamination of the sample(s), or having a sample of insufficient size to adequately assess the homogeneity of the entity from which it was derived

9.4.5 Circumstances that increase the possibility of a random association (e.g., the suspect is a house painter and the material in question is an architectural paint)

9.5 Example Scenarios for Each Type of Conclusion

The following examples are provided to assist in reaching each type of conclusion. The examples provided are not meant to be binding or all-inclusive.

9.5.1 Physical Fit

9.5.1.1 A Physical Fit conclusion is possible where there is a physical fit (fracture fit) of a paint chip with another paint chip along its broken edge, with a substrate where it was previously in contact, or through corresponding individual characteristics (e.g., surface scratches) that carry across onto the questioned chip from the remaining finish.

9.5.2 Association with Highly Discriminating Characteristics

9.5.2.1 OEM automotive system with at least one aftermarket basecoat or primer layer above the original clear coat

9.5.2.2 OEM automotive system with two or more factory repairs (i.e., three or more total basecoat/clearcoat sequences)

9.5.2.3 Architectural paint system with two or more different layers

9.5.2.4 Automotive system with architectural paint present

9.5.3 Association with Discriminating Characteristics

9.5.3.1 Association of paint in which the typical analysis scheme was performed on mass-produced materials that have numerous features for evaluation (e.g., four-layered OEM automotive paint)

9.5.3.2 Standard OEM automotive paint system

9.5.3.3 OEM automotive paint system with one factory repair of the same basecoat color and layer sequence (i.e., two total OEM basecoat/clearcoat sequences)

9.5.3.4 Single-layered paint for which there is knowledge of substantial discrimination power (e.g., red architectural paint) or product manufacturing distribution information that reduces the potential sources

9.5.3.5 Aftermarket refinish clearcoat and basecoat

9.5.4 Association with limitations

9.5.4.1 Smears rather than chips (one or two layers or a mixture)

9.5.4.2 No elemental analysis performed

9.5.4.3 Partial transfer of an OEM automotive paint system (e.g., chips containing clearcoat and basecoat only)

9.5.4.4 Single-layered paint for which there is limited knowledge of discrimination power and product manufacturing distribution information (e.g., yellow tool paint)

9.5.5 Inconclusive

9.5.5.1 The paints exhibit both similarities and differences such that no meaningful conclusion can be reached.

9.5.5.2 Suspected clearcoat automotive layer transfer in which both vehicles have consistent (indistinguishable) clearcoat chemistries.

9.5.6 Exclusion with Limitations

9.5.6.1 The Exclusion with Limitations conclusion is not usually applicable for paint comparisons.

9.5.7 Exclusion/Elimination

9.5.7.1 Exclusionary difference in physical characteristics (e.g., different color, different layer structure)

9.5.7.2 Exclusionary difference in chemical composition (e.g., different binders or fillers present, different ratios/amounts of components that exceed the variation observed in the sample)

9.6 Example Wording for Types of Conclusions

These are only examples. Each laboratory determines the specific wording to be used in its reports. In addition to text similar to below (or similar to the examples throughout this document), the specific techniques used shall also be included as part of the report.

9.6.1 Physical Fit

9.6.1.1 “Examination and comparison of Items 1 and 2 revealed corresponding fracture contours, surface configurations, and layer structures. This provides extremely strong support for the proposition that the items originated from the same damaged source as opposed to the proposition they originated from different damaged sources (**Physical Fit**).”

9.6.2 Association with Highly Discriminating Characteristics

9.6.2.1 “Examination and comparison of the Item 1 questioned paint with Item 2 revealed they are consistent with respect to their observed and measured physical and chemical properties (e.g., layer sequence and chemical composition of corresponding layers) when analyzed using (*insert analytical techniques here*). It is therefore concluded that the Item 1 questioned paint recovered from the victim’s clothing corresponds to the Item 2 paint and therefore originated either from that vehicle or from another source of automotive paint having the same distinct characteristics (**Association with Highly Discriminating Characteristics**). This type of conclusion was reached because the questioned and known paints both exhibit characteristics that are atypical of original equipment manufacturer (OEM) paints. Due to the presence of (*insert feature here*) it is unlikely that other vehicles produced at the same manufacturing plant in approximately the same time frame would exhibit the same feature(s). Furthermore, any other vehicles painted in the same distinctive manner would have to be damaged and missing paint in order to be considered viable sources of the questioned paint.”

9.6.3 Association with Discriminating Characteristics

9.6.3.1 “Examination and comparison of the Item 1 questioned paint with Item 2 revealed they are consistent with respect to their observed and measured physical and chemical properties (e.g., layer sequence and chemical composition of corresponding layers) when analyzed using (*insert analytical techniques here*). It is therefore concluded that the Item 1 questioned paint recovered from the victim’s clothing corresponds to the Item 2 paint and therefore originated either from that vehicle or from another source of automotive paint having the same distinct characteristics (**Association with Discriminating Characteristics**). This type of conclusion was reached because other vehicles produced at the same manufacturing plant and painted with the same type of paint system would also be indistinguishable.

The techniques utilized in this comparative analysis can typically distinguish paint systems from different assembly plants.”

9.6.3.2 “Examination and comparison of the Item 1 green questioned paint recovered from the clothing with the Item 2 can of spray paint revealed the paints are consistent with respect to their observed and measured physical and chemical properties (e.g., color, texture, and chemical composition) when analyzed using (*insert analytical techniques here*). It is therefore concluded that Item 1 either originated from the Item 2 spray paint can or from another source of paint with the same distinct characteristics (**Association with Discriminating Characteristics**). This type of conclusion was reached because spray paints are mass-produced, and other paint cans manufactured to the same specifications as Item 2 would also be indistinguishable from this paint. The techniques utilized in this comparative analysis can typically distinguish most spray paint products.”

9.6.4 Association with Limitations

9.6.4.1 “The Item 1 questioned paint recovered from the scene consists of a smear of (*insert description*). Examination and comparison of Item 1 with Item 2 revealed they are consistent in (color, general binder type, etc.). Due to the limited quantity and abraded nature of the questioned sample, limited comparisons were performed. It is therefore concluded that Item 2 cannot be eliminated as a possible source of the questioned paint recovered from Item 1 (**Association with Limitations**). This type of conclusion was reached due to the limited characteristics available for comparison as a result of the limited size and poor condition of the questioned sample.”

9.6.5 Inconclusive

9.6.5.1 “Examination and comparison of the Item 1 possible transfer on Vehicle 1 to the clearcoats of Vehicles 1 and 2 revealed that the vehicles have similar clearcoat chemical compositions to each other and to the possible transfer, and therefore, no meaningful conclusion could be drawn (**Inconclusive**).”

9.6.6 Exclusion/Elimination

9.6.6.1 “Examination and comparison of the Item 1 questioned paint with Item 2 revealed they are different with respect to (*insert characteristics here*). It is therefore concluded that the questioned paint recovered from the scene did not originate from the reference area/panel of the vehicle represented by Item 2 (**Exclusion/Elimination**).”

9.7 Other considerations

9.7.1 Standard methods of analysis (e.g., ASTM) shall be used when they are available. Other technology can be employed if it has been reported in peer-reviewed sources and has been validated according to ISO/IEC 17025.

9.7.2 Activity factors that could increase the overall assessment of the significance

9.7.2.1 The paint was applied wet to the surface (e.g., spray paint droplets) as opposed to being smeared on an item after the paint was dry

9.7.2.2 Paint embedded in clothing rather than loosely adhered

9.7.2.3 Location or directionality of a transfer that assists in reconstruction of events (e.g., vehicle collision)

9.7.2.4 Cross-transfer of paints

9.7.3 Activity factors that could decrease the overall assessment of the significance

9.7.3.1 Reasonable explanation as to why there was a transfer of paint(s) (e.g., individual was a painter with access to the location)

9.7.3.2 Environment with a high background of paint (e.g., busy intersection)

9.7.4 Examples of additional wording of information related to activity level

9.7.4.1 “The physical characteristics of the paint on Item 1 establishes that the paint was wet when applied.”

9.7.5 In instances in which two or more associations are being reported (e.g., cross-transfers or multiple transfers), each association should be reported separately. Then additional text can be included describing whether and how the multiple reported associations could affect the overall significance assessment and conclusions arising from the totality of the examination results.

9.7.5.1 Example report wording (cross-transfer). “The presence of a three-layered paint chip on Vehicle A that is indistinguishable from the known paint from Vehicle B and a four-layered paint chip on Vehicle B that is indistinguishable from the known paint from Vehicle A provides stronger support for the transfer of paints between the two vehicles than either transfer alone.”

9.7.5.2 Example report wording (multiple transfers). “The presence of a three-layered OEM paint chip on Vehicle A that is indistinguishable from the bumper paint from Vehicle B and a four-layered aftermarket paint chip on Vehicle A that is indistinguishable from the hood paint from Vehicle B provides stronger support for the transfer of paints from Vehicle B to Vehicle A than either transfer alone.”

9.7.6 Vehicles can have different paint systems on different panels of the same vehicle. Therefore, it is possible that one known vehicle part differs from questioned sample and is eliminated as a possible source, but that enough similarities exist to warrant the request of additional samples from other parts of the vehicle to determine whether the entire vehicle should be eliminated.

9.7.6.1 Example report wording. “The unknown paint did not come from that area of the vehicle where the known sample was taken (**Exclusion/Elimination**). Vehicles can have different paint systems on different panels of the same vehicle. Further comparisons can be performed if additional known samples are submitted.”

10. Tape Reporting

10.1 For this Practice, “tape” refers to pressure-sensitive tapes, primarily duct tape, electrical tape, and packaging tape, but this practice can also be applied to other types of tapes. Tape is manufactured in different forms/types, which allow for differentiation based on physical characteristics, organic composition, or inorganic/elemental composition.

10.1.1 Forensic tape analysis is typically a comparison of two or more tape pieces/rolls in an attempt to determine if they originated from different sources. If the samples cannot be eliminated as having come from the same roll, forensic tape analysis can provide an assessment as to the significance of that association.

10.1.2 Tape examinations can also include the identification of the tape type or designed use. For duct tapes this might include attempts to determine manufacturer and distribution information.

10.1.3 Tapes contain several components including an adhesive layer and a backing layer. Some tapes (e.g., duct tape) also contain reinforcing fibers located between the adhesive and backing, which could provide additional discrimination potential.

10.2 Analytical methodologies used for tape comparisons have a direct impact on significance assessments. Tape can provide Physical Fit conclusions when there is a realignment of ends/edges between two pieces of tape.

A Physical Fit conclusion is the examiner’s opinion that the possibility is negligible that the compared tapes originate from different torn/cut tape sources. A Physical Fit conclusion is not currently based upon statistically-derived measurements; it is also not based upon exhaustive comparisons to all potential sources.

10.2.1 A comprehensive analytical scheme, unless sample size or condition prohibits it, shall include visual and microscopical examinations to assess physical characteristics and instrumental examinations to assess organic composition and inorganic/elemental composition of the backing, adhesive, and reinforcing fibers (if applicable).

10.2.2 Increased or decreased significance is based on available information for the relevant population (e.g., published discrimination studies, product manufacturing and distribution information, databases).

10.3 Source factors that could increase the significance of an association

10.3.1 Physical fit

10.3.2 Unusual physical features, such as a printed backing

10.3.3 Manufacturing defects

10.3.4 Unusual chemical features, such as an uncommon filler

10.3.5 Unusual or rare type of tape (e.g., limited amount manufactured or limited distribution)

10.3.6 Environmental factors that would affect both the questioned and known tape (e.g., consistent weathering or damage)

10.3.7 Post-manufacturing modification of the tape observed on both samples being compared (e.g., handwriting on tape backing, paint overspray)

10.4 Source factors that could decrease the significance of an association

10.4.1 Common formulation of tape

10.4.2 Limited number of features available for comparison

10.4.3 Limited size

10.4.4 Contamination, degradation, or damaged condition of the sample(s)

10.4.5 Analytical scheme does not include an assessment of both the organic and inorganic/elemental composition of the tape

10.4.6 Analytical techniques do not include an assessment of backing, adhesive, and reinforcement

10.4.7 Minor physical or chemical differences between items being compared that could be a result of sample heterogeneity, contamination of the sample(s), or having a sample of insufficient size to adequately assess the homogeneity of the entity from which it was derived

10.4.8 Circumstances that increase the possibility of a random association (e.g., limited number of different products sold in a given area)

10.5 Example Scenarios for Each Type of Conclusion

The following examples are provided to assist in reaching each type of conclusion. The examples provided are not meant to be binding or all-inclusive.

10.5.1 Physical Fit

10.5.1.1 A Physical Fit conclusion is possible where there is a physical fit of an end/edge of a piece of tape with another end/edge of a piece of tape or roll of tape, or through corresponding individual characteristics (e.g., surface scratches, scrim alignment) that carry across from one tape to the other.

10.5.2 Association with Highly Discriminating Characteristics

10.5.2.1 Post-manufacturing mark on the items (e.g., both known and questioned exhibit similar damage, handwriting on tape backing, paint overspray)

10.5.3 Association with Discriminating Characteristics

10.5.3.1 Association of tape in which the typical analysis scheme was performed on mass-produced materials that have numerous features for evaluation (e.g., two duct tapes, two electrical tapes, two packaging tapes)

10.5.3.2 A reduced analytical scheme was conducted, *as long as* the physical characteristics, organic composition, and inorganic/elemental composition of the tape have been assessed to the extent possible. For instance, it is a frequent occurrence that adhesives are too damaged to measure an accurate overall thickness; in such an instance, this type of conclusion can still be reached if the tape has been comprehensively analyzed otherwise.

10.5.4 Association with Limitations

10.5.4.1 Adhesive residue compared to a tape

10.5.4.2 No adhesive remaining on a tape backing

10.5.4.3 Reduced analytical scheme in which either the physical characteristics, organic composition, or inorganic/elemental composition of the tape has not been satisfactorily assessed (e.g., no inorganic analysis of duct tape adhesives, no elemental analysis of electrical tape backings, no polarized light microscopy analysis of packaging tape backings)

10.5.4.4 When the cause of minor physical or chemical differences between items being compared cannot be determined (i.e., the differences could be a result of sample heterogeneity, contamination of the sample(s), or having a sample of insufficient size to adequately assess the homogeneity of the entity from which it was derived) but the samples are otherwise indistinguishable

10.5.5 Inconclusive

10.5.5.1 The questioned item is too damaged/degraded/contaminated to conduct most examinations.

10.5.6 Exclusion with Limitations

10.5.6.1 The Exclusion with Limitations conclusion is not usually applicable for tape comparisons.

10.5.7 Exclusion/Elimination

10.5.7.1 Exclusionary difference in physical characteristics (e.g., different color, different layer structure)

10.5.7.2 Exclusionary difference in chemical composition (e.g., different elastomers or fillers present, different ratios/amounts of components that exceed the variation observed in the sample)

10.6 Example Wording for Types of Conclusions

These are only examples. Each laboratory determines the specific wording to be used in its reports. In addition to text similar to below (or similar to the examples throughout this document), the specific techniques used shall also be included as part of the report.

10.6.1 Physical Fit

10.6.1.1 “Based on distinct features of the torn edge of one end of the Item 1 piece of tape and the free end of the Item 2 roll of tape, Item 1 was observed to physically correspond with the end of Item 2. This provides extremely strong support for the proposition that Item 1 originated from and was at one time a part of Item 2 as opposed to the proposition that it originated from and was a part of another used roll **(Physical Fit)**.”

10.6.2 Association with Highly Discriminating Characteristics

10.6.2.1 “Items 1 and 2 were found to be indistinguishable in physical features and chemical composition (*specify techniques*). Further, both items have similar environmental damage on their surfaces. Therefore, Item 1 originated from Item 2 or another roll of damaged tape manufactured in the same manner (**Association with Highly Discriminating Characteristics**). This type of conclusion was reached because other rolls of tape produced at the same manufacturing plant and with the same specifications would also be indistinguishable, but these rolls would not be expected to be damaged.”

10.6.3 Association with Discriminating Characteristics

10.6.3.1 “Items 1 and 2 were found to be indistinguishable in physical features and chemical composition (*specify techniques*). Therefore, Item 1 originated from Item 2 or another roll of tape manufactured in the same manner (**Association with Discriminating Characteristics**). This type of conclusion was reached because other rolls of tape produced at the same manufacturing plant and with the same specifications would also be indistinguishable. Due to differences between tape products, the analytical techniques used in the analysis of these items allow for a high degree of discrimination.”

10.6.4 Association with Limitations

10.6.4.1 “The Item 1 residue is chemically indistinguishable (*specify techniques*) from the adhesive used in the Item 2 roll of tape. Therefore, Item 2 cannot be eliminated as a possible source of Item 1 (**Association with Limitations**). This type of conclusion was reached due to the limited number of characteristics available for comparison between the adhesive and the roll of tape, and because other rolls of tape have been manufactured (including rolls manufactured and distributed by other tape producers) that would have the same adhesive composition.”

10.6.5 Inconclusive

10.6.5.1 “Although there are some similarities between the Item 1 debris and the adhesive from the Item 2 tape, severe contamination of Item 1 by biological fluids precludes a definitive assessment of the relationship between the debris and the tape. Therefore, no conclusion can be reached (**Inconclusive**).”

10.6.6 Exclusion/Elimination

“Examination and comparison of the Item 1 piece of tape with the Item 2 roll of tape revealed they are different with respect to (*insert characteristics here*). It is therefore concluded that Item 1 did not originate from Item 2 (**Exclusion/Elimination**).”

10.7 Other considerations

10.7.1 Standard methods of analysis (e.g., ASTM) shall be used when they are available. Other technology can be employed if it has been reported in peer-reviewed sources and has been validated according to ISO/IEC 17025.

10.7.2 When two or more associations are being reported, each association should be reported separately. Additional text can then be included describing whether and how the multiple reported associations could affect the overall significance assessment and conclusions arising from the totality of the examination results.

10.7.2.1 Example report wording. “Based on the reported results, more than one type of tape was recovered from and concluded to be indistinguishable between the various scenes. These findings could increase the significance of the reported results.”

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