Technical Procedure for the Examination of Glass Evidence

1.0 Purpose – This technical procedure shall be followed for the examination of glass evidence.

2.0 Scope – This document shall be used as a guideline for the forensic examination of glass. These guidelines are used by Forensic Scientists in the evaluation, selection, and application of tests regarding glass comparison and/or glass fracture examination.

3.0 Definitions

- **Range Overlap method in Refractive Index (RI) Determination** – The range of refractive indices for a known standard is defined as the values between the minimum and maximum N_D RI measurements. If the known glass RI measurements produce an average that falls outside of the accepted +/- 0.0001 RI units, this overlap method shall be used. For the refractive indices to be considered indistinguishable, the ranges for the known and unknown must overlap or fall within each other. This method is mostly used for tempered glass which is known to have a wider range of refractive index within one manufactured pane.

4.0 Equipment, Materials, and Reagents

4.1 Equipment

- Polarized light microscope
- Stereomicroscope
- Calipers
- Ultra-sonic cleaner
- Ultraviolet Viewing Cabinet with 254 nm (short) and 365 nm (long) wavelengths
- Glass Refractive Index Measurement System (GRIM)
- X-Ray Fluorescence System (XRF)

4.2 Materials

- Clean paper (brown and/or white)
- Metal tin
- Gelatin capsules
- Tweezers
- Kimwipes

4.3 Reagents

- Acetone - Reagent A.C.S. grade
- Diluted nitric acid solution (5-10 %)
- Mild detergent

5.0 Procedure

5.1 Glass Comparison Procedure

5.1.1 Initial Glass Examination

5.1.1.1 Review the request for analysis.

5.1.1.2 Perform screening, searching, and retrieval of glass evidence from items using the Trace Evidence Section Technical Procedure for the Collection and Preservation of Evidence

5.1.1.3 Separate any potential glass fragments from any other debris as necessary.

5.1.1.4 Determine if the fragments are glass using one or all of the following methods:

5.1.1.4.1 Use a polarized light microscope to determine if the fragments are glass (isotropic). Insert the analyzer (cross the polars). If the particle is glass, the particle should remain extinct (no interference colors or rainbows). Rotate the stage 360 degrees. There should be no interference colors during rotation.

5.1.1.4.2 Place particle into an organic solvent such as acetone. If the particle exhibits soluble characteristics, it is not glass.

5.1.1.4.3 Glass fragments can be differentiated from plastics by their hardness. If the pressure of a needle/probe causes deformation, the particle is not glass.

5.1.1.5 Document the number, or approximate number of glass fragments and condition of the glass.

5.1.1.6 Clean glass fragments as necessary. This can be done using a solvent such as acetone, or a diluted acid, such as 5 % to 10 % nitric acid. Some fragments may require the use of detergent and/or an ultra-sonic cleaner to remove debris.

5.1.1.7 If possible, examine and compare the questioned glass sample to the known sample for a physical match. Refer to Trace Evidence Section Technical Procedure for Physical Match Analysis.

5.1.1.8 If sample size permits, determine and record the physical characteristics of the glass.

5.1.1.8.1 Color.

5.1.1.8.2 Type (e.g., flat, container, curved, tempered, laminate, etc).

5.1.1.8.3 Thickness using calipers; measured sides must be parallel.

5.1.1.8.4 UV Fluorescence: If the glass has a side/sides that fluoresces under UV light, it is an indicator the glass was made using the "float" manufacturing method.

5.1.1.8.5 Additional notes if applicable to include recording approximate number of fragments and if the glass has any other surface features such as additional coatings, manufacturing or non-manufacturing features (scratches, etc.).

5.1.1.9 Determine the next step in examination.

5.1.1.9.1 If there are physical differences between the unknown and known samples at this step in the procedure, the analysis is complete and the conclusion is reported.

5.1.1.9.2 If all physical characteristics are the same and the samples cannot be distinguished from each other and as sample size permits, continue on to **5.2**.

5.1.2 Elemental Analysis

5.1.2.1 If sample size permits, measure the elemental composition of the glass samples. See the Trace Evidence Section Technical Procedure for X-ray Fluorescence Spectrometer. Effort shall be made to compare known and unknown samples of the approximate same size to ensure the best results. If the sample is too small, the Forensic Scientist shall document this and move on to **5.3**. In general, the XRF analysis for glass requires a sample size of at least 5mm in width. An attempt shall be made to have a flat surface and non-float side in the aim of the x-ray.

5.1.2.1.1 If the sample is float glass (has a side that fluoresces under UV-light), the non-float side shall be placed toward the x-ray detector.

5.1.2.1.2 Print all spectra for each of the known and unknown items. Determine if there are any elemental differences between the known and unknown spectra.

5.1.2.1.3 Export the report results into Excel which has the capability to calculate both the calcium to iron intensity ratio (Ca/Fe) and the strontium to zirconium intensity ratio (Sr/Zr).

5.1.3 Glass Refractive Index Determination

5.1.3.1 If sample size permits, measure the refractive index of the glass sample using the Glass Refractive Index Measurement System. See the Trace Evidence Section Technical procedure for Glass Refractive Index Measurement.

5.1.3.2 Obtain a minimum of five (5) refractive index measurements from different fragments within each sample. This is not always possible with very small samples. If less than 5 readings are possible, it shall be noted in the FA

worksheet. It shall also be noted if the RI readings are *not* within 0.0001 of each other.

5.1.4 Compare all results from the questioned samples to the results from the known samples.

5.1.5 Guidelines for Glass Comparison Result Statements

5.1.5.1 Positive

5.1.5.1.1 Positive physical match.

5.1.5.1.1.1 Example: The submitted samples (questioned and known) came from the same pane or object and no other.

5.1.5.1.2 Association between items.

5.1.5.1.2.1 The samples (questioned and known) could have originated from the same source. This opinion would occur when the samples are consistent in comparison of physical properties, refractive index, and/or elemental composition. The refractive index must fall within the range of +/- 0.0001 RI units. (However, if the known glass produces a wider range of refractive index measurements than +/- 0.0001 RI units, the range overlap method may be used when comparing questioned and known glass refractive measurements.)

5.1.5.1.2.2 Example: Examination showed the glass in Item A is consistent in physical properties, refractive index, and elemental composition with the glass in Item B. These fragments could have shared a common origin.

5.1.5.1.3 Item searched, glass was found.

5.1.5.1.3.1 Example: Examination of Item A revealed the presence of (a) broken glass fragment(s).

5.1.5.2 Negative

5.1.5.2.1 No association.

5.1.5.2.1.1 This opinion would come from evidence where analysis showed a difference between questioned and known samples in one or more

of its properties (physical, optical, or elemental). The samples (questioned and known) could not have come from a common source.

5.1.5.2.1.2 Example: Item A and Item B were not consistent in physical properties, optical properties, and/or elemental composition. These items could not have shared a common origin.

5.1.5.2.2 Item searched, glass was not found.

5.1.5.2.2.1 Example: Examination of Item A did not reveal the presence of any broken glass fragment(s).

5.1.5.3 No known glass standard was submitted.

5.1.5.3.1 No analysis shall be performed on a case without a sufficient known sample. However, there may be probative value in a search for glass. In such cases, the Forensic Scientist Manager of the Trace Evidence Section shall be notified and the evidence examined on a case-by-case basis.

5.1.5.3.2 Example: Due to the fact that no known glass standard was submitted for comparison purposes, the evidence is being returned unworked. Should a known glass standard become available, please resubmit this item along with the known standard. If you have any questions, please contact the Forensic Scientist who issued this report.

5.1.5.4 Limited Sample

5.1.5.4.1 Sometimes the limited questioned sample does not allow for the performance of all/any methods of analysis for comparison. In this case, the Forensic Scientist must note that there is insufficient sample for comparison purposes.

5.1.5.4.2 Example: The fragment(s) recovered from Item A were too small for analysis.

5.1.5.4.3 Example: Due to the limited size of the glass fragments in Item A, only refractive index measurement could be performed.

5.1.5.5 No Analysis

5.1.5.5.1 No analysis is performed.

5.1.5.5.1.1 Example: Item A was not analyzed.

5.1.5.5.2 No analysis is performed due to the results of the DNA analysis.

5.1.5.5.2.1 Example: Based on the results of DNA analysis, the above listed evidence is being returned unanalyzed. If you have any questions, please contact the Forensic Scientist who issued the report.

5.1.6 Sampling and Sample Selection

5.1.6.1 No sampling is performed. When sample selection occurs, it shall be based on the Forensic Scientist's training and experience.

5.1.6.2 If, at any point during the course of examination, the items are found to be inconsistent with one another, analysis may be halted and a lab report shall be issued stating a negative finding.

5.1.6.3 If no glass standards are submitted, the evidence shall be returned to the agency unworked.

5.1.6.4 If DNA analysis is being performed on the evidence in the case, based on the results of the DNA analysis, the glass evidence may be returned unworked.

5.1.7 Standards and Controls – There shall be at least one known glass standard submitted in each case for comparison purposes, unless otherwise approved for analysis by the Forensic Scientist Manager of Trace Evidence.

5.1.8 Calibrations – No additional calibrations or performance checks are required. See associated technical procedures for instrumental performance checks.

5.1.9 Maintenance – No additional instrument maintenance are required. See associated technical procedures for instrumental maintenance.

5.1.10 Uncertainty of Measurement – N/A

5.2 Glass Fracture Examination

5.2.1 These notes and reports are generated only at the specific request for direction of force or type of break examination.

5.2.1.1 Physical Reconstruction

5.2.1.1.1 Perform a physical match analysis following the Trace Evidence Section Technical Procedure for Physical Match Analysis. When physically matching glass fragments, it is important to pay attention to any ridges, hackle marks, or

surface features such as scratches or reams that might be present.

5.2.1.2 Types of Fractures

5.2.1.2.1 Low Velocity Impact Fractures

5.2.1.2.1.1 Record the presence of radial and/or concentric cracks. In addition, note the presence of Wallner lines on the radial cracks nearest the point of impact.

5.2.1.2.1.2 Determine the direction using the 4R Rule. (Ridges on Radial Cracks are at Right angles to the Rear.)

5.2.1.2.2 High Velocity Impact Fractures

5.2.1.2.2.1 A high speed projectile striking glass will produce a cone or crater. If the projectile passes through the glass, the opening on the exiting side will be larger than the opening on the entry side.

5.2.1.2.2.2 Radial Cracks can also develop from high velocity impacts. The sequence of multiple impacts can be deduced when the cracks caused by a subsequent impact terminate at previously formed cracks.

5.2.1.2.3 Thermal Factures - In non-tempered glass a typical heat crack is curved, has a smooth edge, and no indication of a point of origin of the crack. Localized heating of thick pieces of glass can cause cracks with a feathered appearance. The side to which the heat was applied cannot be determined from fracture edges.

5.2.1.3 Guidelines for Glass Fracture Result Statements

5.2.1.3.1 Determination of Direction of Force

5.2.1.3.1.1 Example: The ___ (item) was broken by a force in the direction from “inside to outside” or “outside to inside.”

5.2.1.3.2 No Determination of Direction of Force

5.2.1.3.2.1 Example: No determination could be made concerning the direction of force.

5.2.2 Sampling and Sample Selection

5.2.2.1 No sampling is performed. Sample selection is based on the Forensic Scientist's training and experience.

5.2.2.2 All items submitted shall be examined.

5.2.3 Standards and Controls – N/A

5.2.4 Calibrations – This procedure does not require any calibrations or performance checks. However, it does utilize instruments that require performance checks. See the individual technical procedures for the operations of those instruments.

5.2.5 Maintenance – No maintenance is required in this procedure. However, the procedure does utilize instruments that require maintenance. See the individual technical procedures for the operations of those instruments.

5.2.6 Calculations – N/A

5.2.7 Uncertainty of Measurement – N/A

6.0 Limitations

6.1 No analysis shall be performed on a case without a sufficient known sample. However, there may be probative value in a search for glass. In such cases, the Forensic Scientist Manager of the Trace Evidence Section shall be notified and the evidence examined on a case-by-case basis.

6.2 Size of the known and unknown samples may limit the number of analyses performed on each sample. It must be documented in the notes which tests were and were not performed.

6.3 The 4R rule, in general, has limitations for laminated glass, tempered glass, or small windows held in a tight frame.

7.0 Safety

7.1 Glass slides have sharp edges.

7.2 High temperatures may be produced by the hot stage using the GRIM.

7.3 The X-ray Fluorescence (XRF) emits x-rays. Become familiar with the safety section of the XRF manual. NEVER open the lid while the x-rays are on.

8.0 References

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9.0 Records – N/A

10.0 Attachments – N/A

Revision History		
Effective Date	Version Number	Reason
09/17/2012	1	Original ISO Document
09/30/2013	2	Removed examples of result statements 5.1.5.1.3.1 and 5.1.5.2.2.1; Reworded 5.1.5.2.1.2 and 5.1.5.1.2.2
10/18/2013	3	Added issuing authority to header