Glass Fractures

Scientific Working Group for Materials Analysis (SWGMAT)

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1. Scope

This document describes the guidelines for assessing fracture features as they relate to forensic glass analysis.

2. Reference Documents

2.1. Scientific Working Group for Materials Analysis Documents

Trace evidence recovery guidelines
Quality assurance guidelines

2.2. American Society for Testing and Materials Standard

C1256 Standard Practice for Interpreting Glass Fracture Features

3. Terminology

Concentric cracks are fractures forming in an approximately circular pattern around the point of impact. They are usually in straight segments that terminate in an existing radial crack.

Cone or crater (Hertzian cone) is a funnel-shaped area of damage caused by a high-velocity impact.

Hackle is a line on the crack surface running parallel to the local direction of crack spreading.

Radial cracks are fractures extending outward from the point of impact.

Ream is an imperfection; nonhomogeneous layers of flat glass.

Wallner lines (ridges) are rib-shaped marks with a wave-like pattern. Wallner lines are called rib marks or ridges to describe their shape and are almost always concave in the direction from which the crack was propagating.

4. Summary of Guideline

This guideline discusses the characterization and assessment of the significance of fracture features in glass as observed through microscopic and macroscopic examination. This guideline also describes the reconstruction of broken glass objects.

5. Significance and Use

Fracture patterns are unique. Fracture features in a piece of glass reflect the nature of the glass and the direction of travel and velocity of the breaking object. Glass fracture examinations can provide information as to the direction of the breaking force and the sequence of multiple impacts. A physical match of two pieces of glass establishes that they came from the same source to the exclusion of all other sources.

6. Sample Handling

Extreme care should be taken to prevent further breakage of the glass during any phases of packing, shipping, or unpacking of glass shards. Proper sample preparation and technique are prerequisites for obtaining reliable results. See the *Scientific Working Group for Materials Analysis Collection, Handling, and Identification of Glass.*

7. Analysis

7.1. Physical Reconstruction

Ensure that all pieces of glass could have originated from the same object *(*see the *Scientific Working Group for Materials Analysis Initial Examinations of Glass).* Coatings, the float surface, and other features may be used to aid in the orientation of glass pieces prior to reconstruction. Align the edges of two pieces of glass that appear to match physically. Two pieces of glass will not slip past one another with gentle pressure when there is a physical match. Examine the broken edges using low-power light microscopy to observe corresponding Wallner lines (ridges) and/or hackle marks on the matching pieces of glass. Features, such as surface scratches or ream, may also match across a fracture.

7.2. Types of Fractures

Low-velocity impact, high-velocity impact, and thermal fractures may be observed in glass and can be differentiated.

7.2.1. Low-velocity impact fractures

7.2.1.1. Low-velocity projectiles produce cracks in the glass, which radiate outward from the point of impact (radial cracks). If a pane is firmly held on all sides, concentric cracks can form around the point of impact. The sequence of multiple impacts can be deduced when the cracks caused by a subsequent impact terminate at previously formed cracks.

7.2.1.2. By observing the Wallner lines (ridges) on the radial cracks, the direction of breaking force can often be determined. Observe only the Wallner lines on the radial cracks nearest the point of impact. If the impact site is not preserved, the glass must be reconstructed. The original orientation of the glass must be known to complete the determination.

7.2.1.3. The ridges (Wallner lines) on radial cracks nearest the point of impact are at right angles to the side opposite, or to the rear, of the impact. This phenomenon is referred to as the 4R rule, (Ridges on Radial cracks are at Right angle to the Rear.) The 4R rule is unreliable for laminated glass, tempered glass, and small windows tightly held in a frame (Koons et al. 2002).

7.2.2. High-velocity impact fractures

7.2.2.1. A high-speed projectile striking a piece of glass will produce a cone or crater. If the projectile passes through the glass, the opening on the exit side will be larger than the opening on the entry side. If the impact site is not preserved, the glass must be reconstructed to observe any coning effects. However, because of the small size of the shattered fragments at the impact site, the reconstruction of a sufficient portion of the object to display coning effects may not be possible. The size of the hole and the diameter of the crater cannot be used to reliably predict the size of the projectile. Projectiles that pass through the glass at an angle to the surface produce an elongated hole.

7.2.2.2. Radial cracks may also develop from high-velocity impact (see Section 7.2.1.3 for the 4R rule). The sequence of multiple impacts can be deduced when the cracks caused by a subsequent impact terminate at previously formed cracks.

7.2.3. Thermal fractures

In nontempered glass a typical heat crack is curved, has a smooth edge, and has no indication of the 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 (Frechette 1990).

8. Considerations

Glass fragments that are reconstructed with coinciding edges came from the same object. If the direction of impact and/or the sequence of impact have been determined, they should be reported.

9. References

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