GUIDELINE FOR THE FORENSIC EXAMINATION OF VISUAL CHARACTERISTICS OF CONTROL AND RECOVERED SAMPLES OF GLASS

DOCUMENT TYPE:	REF. CODE:	ISSUE NO:	ISSUE DATE:
GUIDELINE	**PGT-GDL-007**	**001**	**12.12.2022**

TABLE OF CONTENTS

1. AIMS ... 2
2. SCOPE ... 2
3. TERMS AND DEFINITIONS ... 2
4. INTRODUCTION ... 2
4.1 Principle and use of visual glass examination and comparison ... 2
4.2 Limitations ... 2
5. METHODOLOGY ... 3
5.1 Sample cleaning ... 3
5.2 Thickness of glasses ... 3
5.3 Bulk Colour ... 4
5.4 Coatings ... 4
5.4.1 Tin (Float Glass) ... 4
5.4.2 Specialised Glasses ... 5
5.4.3 Temporary Coatings ... 5
5.5 Interferometry ... 5
6. REFERENCES ... 6
7. AMENDMENTS TO PREVIOUS VERSION ... 6

GENERAL REMARK

This guideline assumes prior knowledge in the forensic discipline. It is based on consensus among the relevant forensic experts and reflects the accepted practices at the time of writing. The requirements of the judicial systems are addressed in general terms only.

1. AIMS

This guideline describes the forensic examination of visual characteristics of control and recovered samples of glass.

The guideline is aimed towards experts in the field of the forensic examination of glass.

2. SCOPE

This guideline provides recommendations and information about visual examination techniques, with related components, accessories, test routines and sample preparation of the glass pieces and fragments.

LIMITATION: This guideline reflects the European Forensic Glass Community´s recommendation at the time of writing. This guideline does not serve as a textbook in the field of characterisation of physical properties of glass.

3. TERMS AND DEFINITIONS

For the purposes of this guideline, the relevant terms and definitions given in ENFSI documents, the ILAC G19 “Modules in Forensic Science Process”, as in standards like ISO 9000, ISO 17020 and 17025 apply. Also, refer to the main document Best Practice Manual for the Forensic Identification and Comparison of Glass (PGT-BPM-002).

4. INTRODUCTION

The visual characterisation of glass samples and fragments encompasses the initial steps in the investigation of glass evidence. The examination of visual physical features is non-destructive and can often provide the scientist with important information as to the general type of glass under investigation.

4.1 Principle and use of visual glass examination and comparison

Different types of glasses, such as, plain flat glass, tempered (or toughened) glass, laminated glass, patterned glass, are manufactured in slightly different ways. As a result, the visual characteristics can be typical of the method of manufacturing of the glass and can assist in identifying its source. Moreover, the visual examination can assist the scientist in his/her expectation of other physical and chemical properties associated with the glasses under consideration.

4.2 Limitations

Any visual examination of glass fragments and pieces may be limited due to:

- the size and amount of sample
- whether it has an original thickness
- whether it has an original surface

- availability of equipment
- contamination/dirt

5. METHODOLOGY

5.1 Sample cleaning

Any impurities present on the sample surface should be documented, before removal and, if forensically significant, be analysed. Ideally, a photograph of the sample, prior to cleaning, should be taken and retained as a permanent record. For example, samples of glass, held in window or door frames may bear traces of paint, which may require preservation for future examinations.

Depending upon the sample the impurities can be removed from the glass by washing with water, diluted acids or suitable solvents in suitable container. The glass sample can be 'scrubbed' with a tissue or a cotton swab if its size is such that this can be done without risk of losing the fragment. Cleaning should only be performed when there is only a small risk of losing the fragment.

5.2 Thickness of glasses

This can only be measured if the glass has the two original surfaces produced during manufacture. Caution must be paid to mirrored surfaces that are non-genuine original surfaces, which are sometimes produced by fracturing of the glass.

Calibrated Micrometres or Vernier callipers should be used to accurately measure thicknesses; although a ruler can be used if only an estimate of thickness is required. To increase the accuracy, replicate measurements can be done (e.g. three measurements or more, depending on the size of pieces). For toughened/tempered glass, the thickness of several pieces or cubes may be measured. Values should be recorded to establish any range and an average thickness; this will also assist in determining if more than one type of glass is present in the sample, that is to identify a potential mixture of glass types.

Thickness and surface topography can also assist in determining the type of glass under consideration.

Pattern glass has one side that is embossed and a smoother opposing surface.

Glasses produced with older methods, such as plate and crown, may vary in thicknesses across a pane and this needs to be considered when taking measurements and comparing the thickness of control and recovered samples.

Laminated glasses should be measured as whole and with the layers split, and the individual thickness of each layer determined, particularly if more than one type of glass is present within the layers. For example, laminated glasses used in trains or as bullet proof windows may have mixed layers of toughened and plain glasses.

Glasses that are produced from moulds or blown, such as containers and bottles, can have highly variable thicknesses, often between the sides and the base, the latter of which would be thicker.

Recovered glass fragments bearing original surfaces, suitable for thickness measurement, can be compared against the control sample to determine if these are indistinguishable or not. Similarities can be established by determining if the recovered glass is within the range of the control sample or by a statistical test such as the Student-T test.

5.3 Bulk Colour

The bulk colour or tint of a control sample will assist in the comparison with recovered fragments and in classification as to the potential origin.

In order to establish the bulk colour or tint it is essential to examine the glass on a white surface. The light source should be the same when investigating recovered and control samples. The colour must be recorded when orientated on each of its flat surfaces and also edge on. If colour is present on all sides then there is a coloured tint present. If, however, the colour is lost when examined on its edge, then the glass is not truly tinted and the colour is due to properties imparted by manufacture.

A number of tints can be produced in glass by the addition of a variety of compounds. Modern glass, especially those used in vehicles may have tinted windows due to the presence of iron oxides or vanadium oxide, for example.

Glasses, originating from stained glass windows, such as those from churches or glass vases can all be highly tinted and the colour visible can provide an indication as to compounds added to impart the colour.

A few examples have been provided in the table below and the colour will depend upon the oxidation state of the element concerned [1,2].

Element	Colour
Iron	Green, brown
Chromium	Green, yellow, pink
Arsenic	Yellow
Vanadium	Green, blue, grey
Cobalt	Blue
Nickel	Smoky

5.4 Coatings

5.4.1 Tin (Float Glass)

Most window glass is produced by the float manufacturing process; whereby molten glass is fed on to a bath of molten tin. The density of the soda-lime glass is less than that of tin and hence floats and creates glass with smooth surfaces, which is optically free of distortion. As a result, a thin layer of tin will be present on one surface of glass produced by this method. The presence of a tin layer can be readily identified using a UV light source (as contained in a box for example or via the use of a microscope with UV illumination) at a wavelength of 254nm. The tin coated surface will fluoresce (usually yellow to green). It is often useful to have two pieces of glass from the same item and look at opposing surfaces under UV, to confirm that one side fluoresces and the other does not (looks dark). A permanent marker pen should be used to either colour or label the float surface; so this can be readily identified when preparing samples for refractive index measures and analysis. The presence of a float surface might also be seen on GRIM, whereby a fragment will be seen with a solid dark edge that does not disappear during testing, but just varies in light intensity, as the refractive index of the oil changes.

Some older glasses and those produced by being blown etc., may also fluoresce under UV, but can be differentiated from float glasses, as the fluorescence tends to lie within the bulk rather than on the surfaces.

If there is any doubt about whether or not the fluorescence originates from the surface or not, then that surface can be scratched to remove any surface coating; the newly exposed surface will not fluoresce (i.e. absorbs the light and appears darker). However, any bulk fluorescence will remain unchanged.

5.4.2 Specialised Glasses

A wide range of coatings can be added during manufacture, for window glasses produced by the float method, usually to the opposing float surfaces. Typical examples of specialised coatings are those used for self-cleaning windows, solar control, and thermal insulation. Some solar control glasses are tinted and also tend to have a coating that may be seen as a blue or bronze colour with oblique lighting with the naked eye or by using low power microscopy.

Manufacturers produce a wide variety of coatings which may or may not be readily visible to the naked eye or under low power microscopy.

Some coatings used on vehicles can be seen as a hard black layer around the edges of the front and rear windscreens. In addition, some of the windscreens will contain fine metal wires that comprise the heating elements in these windows.

Any potential coating can usually be seen by observing the surfaces with oblique white light. The presence of a coating can be confirmed by scratching away the potential layer to observe any differences with the glass below i.e. the newly exposed surface will not have the coating present and not exhibit the colour observed with the coating seen obliquely.

5.4.3 Temporary Coatings

Some polymer-based coatings may be temporary and added by the manufacturer to protect surfaces during transportation and installation.

Self-adhesive or static coatings may also be added by the end user, such as an anti-glare films or advertising posters in shops. These are often readily visible on larger fragments and the scientist should be aware of their presence as additional evidence for testing or for physical fit construction.

Many television screens and mobile phones (consumer electronics) will have glass screens to aid protection and many may bear a coating and electronics on one side.

The scientist must be aware that some windows installed in door and window frames may have putty or other sealant material used for securing the panes in place. In addition, some may have paint around the edges of the glass, when painted in situ. As such recovered fragments of glass or the debris from an item may have this additional evidence – which should be retained accordingly.

Note: the identification of a coating, including tin, on recovered fragments with an original surface may be difficult to determine at this stage unless these are greater than 0.5 mm^2 in size. It is always recommended than any coating potentially observed on a recovered fragment is compared to that seen on the control. Additionally, any observation should be analysed using SEM/EDX, for example, to establish the composition, which will aid in establishing the type of glass under consideration.

5.5 <u>Interferometry</u>

Interferometry is derived from Phase Contrast Microscopy usually conducted using a high-power microscope with an objective that uses two semi-silvered mirrors that splits a beam of monochromatic light, as used by the Mirau Interferometer objective for example.

Part of the incident light beam is reflected from surface of the fragment and the other from the mirrors. The light reflected from the surface of the glass recombines with the light beam reflected from the reference mirrors giving rise to an interference pattern superimposed on the image of the glass surface. The ‘interferogram’ shows the topography of the surface, which appears as a contour map with alternating fringed bands of light and dark from the respective constructive and destructive interference, due to the differences in distance the two beams have travelled.

The image can be obtained by either tilting a reference mirror or the glass surface. Most forensic laboratories use the latter, whereby the fragment is seated on a small tilting stage.

The fragment of glass should be cleaned and then mounted on a stub which is then seated on the tilting stage.

A standard x10 objective with x10 eyepieces using white light is used focus on the fragment surfaces in the field of view and to tilt the glass as flat as possible, then seen as a mirrored surface. An appropriate monochromatic filter put in place along with the Mirau objective. The fine focus adjustment is used to focus on the surface of the fragment and the stage tilted slightly until an interference pattern is obtained.

The interference pattern will be characteristic of the type of glass under investigation. Any recovered fragment must be at least 0.5mm2 and compared to both surfaces of the control sample to established similarities or differences. A photograph of the interferogram will assist in comparing with the control and reference samples.

6. REFERENCES

[1] Phillips, P. (1987), The Encyclopaedia of Glass. Peerage Books, ISBN 0-600-55408-2.
[2] Caddy, B. (ed) (2001), Forensic Examination of Glass and Paint. Anaysis and Interpretation. Taylor & Francis, ISBN 0-7484-0579-8.

7. AMENDMENTS TO PREVIOUS VERSION

Not Applicable