

TENNESSEE BUREAU OF INVESTIGATION

Forensic Services Division

Microanalysis Standard Operating Procedures Manual

Glass Comparison Analysis



Glass Comparison Analysis

1. Scope

The purpose of this analysis is to analyze the physical, optical, and compositional properties of known and question samples of glass and compare the results to determine if the question sample could have shared a common origin with the known sample.

2. Terms and Definitions

Becke line - the bright halo near the edge of a transparent particle immersed in a medium. The halo moves with respect to that edge as the focal plane of the microscope is changed.

Calibration standards - a series of known standards used for calibration of the instrument (i.e., preparation of the analytical curve). A calibration standard containing zero added concentrations of analytes is referred to as a calibration blank.

Calibration verification standard - a single-element or multi-element standard of known concentrations, obtained from a different source than those used for the calibration, used to monitor and verify instrument performance on a daily or case-by-case basis.

Internal standard (ISTD) - an element or isotope either inherent in or added to samples and calibration standards at a known concentration. It is used to correct for differences in sensitivity between samples or among samples and standards.

Isotropic – exhibiting properties with the same values when measured along axes in all directions.

Match point - any combination of temperature and wavelength, at which two media have indistinguishable refractive indices. At the match point, the glass will exhibit minimum contrast and visibility.

Mean – sum of all values divided by total number of values.

Standard Deviation (SD) – statistical measure of the precision for a series of repetitive measurements, also known as sigma, σ .

Standard Reference Material (SRM) - a material or artifact that has had one or more of its property values certified by a technically valid procedure, and is accompanied



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by, or traceable to, a certificate or other documentation which is issued by the National Institute of Standards and Technology (NIST). Standard reference materials are manufactured according to strict specifications and certified by NIST for one or more quantities of interest.

Refractive index (RI) - for a particular transparent medium is the ratio of the speed of light in one media compared to another, mathematically expressed as $n_i = v_1 / v_2$, where refractive index = n_i at a specific wavelength i , and the speed of light in each media are v_1 and v_2 . For glass analysis, v_1 is the speed of light in a vacuum.

Relative Standard Deviation (RSD) – used for comparing the uncertainty between different measurements of varying absolute magnitude. The RSD is calculated from the standard deviation and is expressed as a percentage (%).

Three and four-sigma range – an interval around the mean that is determined by adding 3(or 4)*SD to the mean and subtracting 3(or 4)*SD from the mean.

3. References

ASTM E-1967, Standard Test Method for the Automated Determination of Refractive Index of Glass Samples Using the Oil Immersion Method and a Phase Contrast Microscope.

Foster+Freeman, GRIM3 Glass Refractive Index Measurement System User Manual 07 (November 2004) Software: Glass 2.0.103; Stage Manager 1.0.19.

ASTM E 2330, Standard Test Method for Determination of Concentrations of Elements in Glass Samples Using Inductively Coupled Plasma Mass Spectrometry (ICP-MS).

4. Examination Procedures

4.1. Evidence Types

Any glass item, any item which may have caused glass to break, any item which may have been near glass when it was breaking, and any item which may have come in contact with broken glass. This analysis is generally optimized for modern window and container glasses, however, many older and specialty glasses may be analyzed with minor variations in the procedure. Any variations must be documented per the QAM.

4.2. Instruments and Equipment



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1. General laboratory glassware, plasticware, and equipment
2. Stereomicroscope
3. Drying oven
4. Glass Refractive Index Measurement (GRIM3) system
5. Polarized light microscope
6. Photographic equipment
7. Inductively Coupled Plasma-Mass Spectrometer (ICP-MS)

4.3. Reagents and Chemicals

1. Ethanol
2. Locke Scientific Oil A
3. Locke Scientific Oil B
4. Locke Scientific Oil C
5. Concentrated Nitric Acid, Ultra pure Grade
6. Concentrated Hydrofluoric Acid, Ultra pure Grade
7. Concentrated Hydrochloric Acid, Ultra Pure Grade
8. High Purity Water
9. 1% Nitric Acid Solution
10. 5% Nitric Acid Solution
11. 10% Nitric Acid Solution
12. 50% Nitric Acid Solution
13. Manufacture Supplied Tuning Solution for ICP-MS
14. Single and Multi-element Standard Solutions

4.4. Reagent Preparation

4.4.1. 1% Nitric acid solution

Add 200-500mL of high purity water to a dedicated 1000mL volumetric flask (non-glass). Analytically measure 10mL of high purity nitric acid into a dedicated graduated cylinder (non-glass). Analytically transfer the 10mL of concentrated nitric acid to the dedicated volumetric flask. Make to volume with high purity water. Analytically transfer to a dedicated storage container labeled with the date and initials. Document the solution in the reagent log.

4.4.2. 5% Nitric acid solution

Add 200-500mL of high purity water to a dedicated 1000mL volumetric flask (non-glass). Analytically measure 50mL of high purity nitric acid into a dedicated graduated cylinder (non-glass). Analytically transfer the 50mL



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of concentrated nitric acid to the dedicated volumetric flask. Make to volume with high purity water. Analytically transfer to a dedicated storage container labeled with date and initials. Document the solution in the reagent log.

4.4.3. 10% Nitric Acid Solution

Add 200-500mL of high purity water to a dedicated 1000mL volumetric flask (non-glass). Analytically measure 100mL of high purity nitric acid into a dedicated graduated cylinder (non-glass). Analytically transfer the 100mL of concentrated nitric acid to the dedicated volumetric flask. Make to volume with high purity water. Analytically transfer to a dedicated storage container labeled with date and initials. Document the solution in the reagent log.

4.4.4. 50% Nitric Acid Solution

Add 200-500mL of high purity water to a dedicated 1000mL volumetric flask (non-glass). Analytically measure 500mL of high purity nitric acid into a dedicated graduated cylinder (non-glass). Analytically transfer the 500mL of high purity nitric acid to the dedicated volumetric flask. Make to volume with high purity water. Analytically transfer to a dedicated storage container labeled with date and initials. This is an example of making 50% Nitric acid. Smaller volumes can be prepared. Document the solution in the reagent log.

4.4.5. P/A stock solution

Analytically pipette 100uL of 1000ug/mL (1000 ppm) of Al, Mg, Ba, Fe, Sr, Sb, Pb and Ti primary standard solutions into a dedicated 100mL volumetric flask (non-glass). Make to volume with 1% nitric acid. Analytically transfer to a dedicated storage container labeled with date and initials. Document the solution in the reagent log. This solution is stable for approximately six months. This solution will contain 1.0ppm Al, Mg, Ba, Fe, Sr, Sb, Pb and Ti.

4.4.6. P/A working solution

Analytically pipette 10,000uL (10mL) of P/A stock solution into a dedicated 100mL volumetric flask (non-glass). Make to volume with 1% nitric acid. Analytically transfer to a dedicated storage container labeled with date and initial. Document the solution in the reagent log. This solution is stable for



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approximately two months. This solution will contain 100 ppb ^{27}Al , ^{24}Mg , ^{138}Ba , ^{57}Fe , ^{88}Sr , ^{121}Sb , ^{208}Pb and ^{47}Ti .

4.4.7. Stock Internal Standard Solution

Pipette 1000uL of 1000ppm Sc, Rh, and Tb standards into a dedicated 100mL volumetric flask (non-glass). Make to volume with 5% nitric acid. Transfer to a dedicated storage container labeled with initials and date. Document the solution in the reagent log. This solution is stable for approximately twelve months. This solution will contain 10ppm Sc, Rh, and Tb.

4.4.8. Stock Standard Solution

Create the following stock standard solutions:

Group I – Pipette 100uL of the 1000 ppm stock solutions of Al, Mg, Mn, Ti, Fe, Sb, Sr, Ba, and Pb into a 100mL volumetric flask (non-glass) and fill with 5% nitric acid. This solution will contain 1ppm of each element in 5% nitric acid. This solution is stable for approximately six months.

Group II – Pipette 10uL of the 1000ppm stock solutions of Rb, Zr, La, Ce, Nd, Sm into a 100mL volumetric flask (non-glass) and fill with 5% nitric acid. This solution will contain 100 ppb of each element in 5% nitric acid. This solution is stable for approximately two months.

Transfer these solutions to dedicated storage containers labeled with initials and date. Document the solution in the reagent log.

Create a second identical set of Group I and Group II stock standards using element standards obtained from a second source. These solutions will be used to make the calibration verification standards.

4.5. Procedural and Chemical Precautions

Refer to the TBI Safety Manual for general safety requirements and hazard information regarding the use of reagents and solvents, and overall safety guidelines.

Protective attire, including laboratory coat, mask, gloves and eye protection should be used when working with clothing and/or bloodstained items.



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Decontamination of a scientist's work area should be performed after each use, but shall be done after analyzing bloodstained items.

Hazardous chemicals shall be used in a chemical fume hood.

When handling concentrated acids, eye protection and laboratory coats shall be worn.

When diluting acids, always add acid to water.

When necessary, consult section and laboratory Material Safety Data Sheets (MSDS) regarding any chemical used in the Microanalysis section.

Label all generated solutions and reagents with appropriate warning stickers.

Use extreme caution when handling hydrofluoric acid. Always wear eye protection, lab coat and gloves. Hydrofluoric acid must be used only in a fume hood. Hydrofluoric acid can only be used when another examiner is present in the section. Refer to the publication, Recommended Medical Treatment for Hydrofluoric Acid Exposure for further precautions and exposure treatments.

The drying oven used for glass analysis is vented to the fume hood to remove acid vapors.

4.6. Limitations

Glass sample sizes should be kept between 4.0mg and 0.75mg. The method is optimized for approximately 2.0mg of sample.

The element suite has been optimized for modern window and container glasses. Other elements may be added to the suite depending on the nature of the glass to be analyzed. For example, K and Ca may be monitored in non-float window glasses or As and Co in older container glasses or foreign manufactured glass. Any additions to the elemental suite will be documented in case notes.

4.7. Procedure

Document submitted samples according to *Microanalysis Quality Assurance Policy*.

4.7.1. Question Glass Examination

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1. Evidence submitted may be photographed for case file documentation.
2. No evidence containers which contain known glass will be open during this time.
3. Containers shall be opened over catch paper when appropriate.
4. If needed, remove question glass from substrate (clothing, etc.).
 - For clothing: empty pockets, cuffs, etc., over catch paper, then scrape/beat clothing with large spatula to remove all debris.
 - For shoes: Probe all areas of sole to remove debris. Shake or beat shoes to dislodge debris from other areas.
 - Other items may be examined microscopically or scraped at the discretion of the forensic scientist.
5. It may be necessary to separate the glass from the debris before proceeding with analysis. This may be done in one of several ways:
 - Shake debris through a sieve series and collect glass.
 - Place debris in tall beaker. Gently rinse debris with water and decant liquid several times (NOTE: only debris heavier than H₂O will remain). Decant H₂O until it appears clean and add ethanol. Decant liquid and allow samples to air-dry or use low heat in a drying oven.
 - Place debris in tall beaker and add nitric acid. (NOTE: All organic matter will be destroyed.) Allow to sit until bubbling ceases. Pour off acid and repeat until acid remains clear. Rinse several times with H₂O then ethanol. Dry as above.
 - Scan debris using stereomicroscope and separate possible glass from debris.
6. Collect remaining debris.
7. Establish Physical Characteristics (If no known glass is submitted, verify that fragments are glass and report that glass was present.)
8. Establish Optical Characteristics
9. Establish Elemental Composition
10. Place analyzed question glass in separate container if there is not sufficient unanalyzed glass for reanalysis.
11. Place unanalyzed question glass in separate container.

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12. Place sealed question glass and sealed debris containers into the evidence container from which it originally came.

4.7.2. Known Glass Examination

1. Evidence submitted may be photographed for case file documentation.
2. No evidence containers containing question glass particles will be opened at the same time as evidence containers of known glass.
3. Containers shall be opened over catch paper when appropriate.
4. Clean glass with soap/hot water in sonicator. Rinse with ethanol and dry in drying oven.
5. Clean glass cannot come in direct contact with the forensic scientist from this point on. This is to prevent contamination of the glass with skin oil.
6. Establish Physical Characteristics
7. Establish Optical Characteristics
8. Establish Elemental Composition
9. Return analyzed glass to evidence containers if there is not sufficient glass for a reanalysis.

4.7.3. Physical Characteristics

1. Verify specimens are glass:
 - a. Place sample on glass slide/petri dish.
 - b. Place slide/dish under polarized microscope.
 - c. Examine samples using a polarized microscope at low magnification (10x-50x), Kohler illumination and with crossed polarizer. Glass is an isotropic substance and will not produce interference colors under crossed polarizers. Rotate stage to verify glass. Extraneous debris may be removed to debris container. Particle glass is then transferred to a Mettler hot stage slide.
2. Document Thickness - Using a micrometer measure thickness of glass. Only fragments with two intact faces can be measured. Characterize using the following criteria:

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Flat Glass Type	Nominal Thickness (inch)	Nominal Thickness (mm)
Microscope slide	.040	1.0
Photographic	.060	1.5
Picture Glass	.080	2.0
Single Strength	.090	2.5
Double Strength	0.120	3.0
5/32"	0.160	4.0
3/16"	0.190	5.0
1/4"	0.230	6.0
5/16"	0.320	8.0
3/8"	0.390	10.0
1/2"	0.490	12.0
5/8"	0.630	16.0
3/4"	0.750	19.0

Derived from ASTM C1036, "Standard Specification for Flat Glass"

3. Document Manufacturing Type as follows:
 - Float - Florescence (short wavelength 254 nm) - on one side only.
 - Roller – Orange peel appearance on surface
 - Molded – Striations (often) on surface
 - Tempered – breaks into small dice; observe stress line in center of glass
 - Laminated – 2 sheets of glass with plastic in between
 - No opinion
 - Typically, manufacturing type can only be determined on larger fragments of glass

4. Document Color:
 - Observe glass on white background
 - Note color in case file
 - Color cannot be determined on very small fragments of glass

5. Document Surface Characteristics as follows:
 - Flat
 - Curved
 - Mirrored
 - Other
 - No opinion



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Typically, surface characteristics can only be determined on larger fragments of glass with two intact faces.

4.7.4. Optical Characteristics

Glass Refractive Index Measurement (GRIM3) System

1. If necessary, break large glass pieces into small fragments using mill.
2. Transfer glass to Mettler slide.
3. Immerse glass fragments into one of the three silicone oils.
 - a. Silicone Oil A – used for most container glasses.
 - b. Silicone Oil B – used for most modern glasses.
 - c. Silicone Oil C – used for most borosilicate glasses.
4. Confirm that the oil being used has been calibrated within the prior 12 months. Recalibrate the oil if necessary.
5. Insert slide into the hot stage.
6. Place the 589nm filter in the light path.
7. Optimize phase contrast.
8. Following procedures outlined in GRIM3 manual, obtain the refractive index at the match temperature of a certified reference glass (such as B7, $n_d(\text{at match temperature})=1.51462$).
9. Compare the RI value of reference glass to the certified value. If it is within 0.00010 of the certified value, proceed with casework. If it is not within 0.00010 of the certified value, possible actions include obtaining RI values for additional edges of reference glass, mounting a new sample of reference glass, and recalibrating the oil.
10. Obtain RI values at the match temperature of several edges of question glass samples. The amount of question sample dictates the number of measurements which can be made. A minimum of three edges is recommended. The analyst has discretion to not use outliers in obtaining the refractive index.



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11. Obtain RI values at the match temperature of several edges of several known glass fragments. The amount of known sample dictates the number of measurements which can be made. However, enough fragments must be analyzed to fully characterize the known. A minimum of ten edges for non-tempered glass and twenty edges for most tempered glasses are recommended. The analyst has discretion to not use outliers in obtaining the refractive index.
12. Analyst may repeat the procedure using 656nm and 488nm filters when there is insufficient question sample for elemental analysis.

4.7.5. Elemental Composition

The elemental suite to be used for this analysis is composed of the following elemental isotopes:

^{24}Mg , ^{27}Al , ^{45}Sc (ISTD), ^{47}Ti , ^{55}Mn , ^{57}Fe , ^{85}Rb , ^{88}Sr , ^{90}Zr , ^{103}Rh (ISTD), ^{121}Sb , ^{138}Ba , ^{139}La , ^{140}Ce , ^{146}Nd , ^{148}Sm , ^{159}Tb (ISTD), $^{206, 207, 208}\text{Pb}$

4.7.5.1. Digestion

1. Wash glass samples separately by soaking fragments for 30 minutes in conc. nitric acid in plastic beakers or tubes. Rinse three times with ultrapure water and three times with ethanol. Dry in oven.
2. Crush samples and SRMs between plastic materials taking care not to puncture the plastic during impact.
3. Weigh five samples of the known glass and SRMs to at least the nearest 0.01mg on a microanalytical balance. Weigh three to five samples of the question glass, depending on the amount of glass available, to at least the nearest 0.01mg on a microanalytical balance. Target sample size for this procedure is about 2mg. Place weighed samples into a non-glass tube. Appropriately label each tube. Handle glass samples with non-metallic instruments. Prepare one additional empty tube labeled as the digestion blank.
4. Add a mixture of conc. hydrofluoric acid, conc. hydrochloric acid, and conc. nitric acid in a 2:1:1 ratio (ex. 500ul HF:250ul HCl: 250ul HNO₃) to each sample, digestion blank, and SRM tubes.



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5. Samples tubes may be capped and placed in an ultrasonic bath for 1 hour.
6. Place **uncapped** tubes in drying oven until dry. Oven should be vented to hood to remove acid vapors.
7. Remove tubes from oven and allow them to cool. Label additional empty tubes as blanks between each exhibit.
8. Add 500uL of 50% nitric acid. Tightly cap tubes and vortex mix the contents of each tube. Return capped tubes to oven for one hour. Vortex mix contents again.
9. Ultrasonicate samples for 1 hour.
10. Allow tubes to sit overnight (up to 36 hours) to aid in complete dissolution of residues.
11. Add 50uL of internal standard solution (10ppm Sc, Rh, and Tb) to each tube.
12. Add 4450uL of ultrapure water to each tube and vortex mix contents. Each tube will contain a 5mL solution with 100ppb Sc, Rh, and Tb internal standard in 5% nitric acid.
13. Allow to sit for approximately one hour.

4.7.5.2. Quantitative Analytical Standard Preparation and Analysis

1. The analytical standards, the SRMs, and the samples may be analyzed as one analytical run or as separate analytical runs. The calibration verification standards shall be analyzed at least before the SRMs and at the end of the run.
2. Label six non-glass tubes S0G1, S1G1, S2G1, S3G1, S4G1, and S5G1 for the Group I Elements.
3. Make solutions according to the following chart.

	S0	S1	S2	S3	S4	S5
ISTD	100uL	100uL	100uL	100uL	100uL	100uL
Stock Sol.	0.0uL	10uL	100uL	500 uL	750 uL	1500 uL
5% Nitric	9900 uL	9890 uL	9800 uL	9400 uL	9150 uL	8400 uL



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Final Conc	0.0ppb	1.0ppb	10.0ppb	50.0ppb	75.0ppb	150.0ppb
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- Label six non-glass tubes S0G2, S1G2, S2G2, S3G2, S4G2, and S5G2 for the Group II Elements.

- Make solutions according to the following chart.

	S0	S1	S2	S3	S4	S5
ISTD	100 uL					
Stock Sol.	0.0 uL	10 uL	50 uL	100 uL	500 uL	5000 uL
5% Nitric	9900 uL	9890 uL	9850 uL	9800 uL	9400 uL	4900 uL
Final Conc	0.0ppb	0.1ppb	0.5ppb	1.0ppb	5.0ppb	50.0ppb

- Label one non-glass tube CVG1 and prepare a 50.0ppb solution using the second source Group I Stock Solution to be used as a calibration verification standard.
- Label one non-glass tube CVG2 and prepare a 5.0ppb solution using the second source Group II Stock Solution to be used a calibration verification standard.
- Fill out the sequence table.
- Establish a calibration table for each element with the concentrations in each standard. Sc will be the ISTD for Al, Mg, Ti, Mn, and Fe. Rh will be the ISTD for Rb, Sr, Zr, Sb and Ba. Tb will be the ISTD for La, Ce, Nd, Sm, and Pb.
- Run sequence and analyze the analytical standards. Confirm that all elements calibration curves are linear and RSDs are 5% or less, except for S0. Print out a calibration report and maintain in case file.

4.7.5.3. Quantitative SRM Preparation and Analysis

- Vortex mix the contents of each tube containing digestion blank, calibration verification standard, SRM samples and blanks.
- Place SRM samples in autosampler tray with a blank placed between each SRM set.
- Enter SRM data into sequence table.



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4. Run the calibration verification standards again at the end of the run.
5. Using the previously established calibration table, perform quantitative analysis on the blanks and SRMs. All values will be reported in the units of mg/kg.

4.7.5.4. Quantitative Sample Preparation and Analysis

1. Vortex mix the contents of each tube containing the calibration verification standard, known samples, question samples and blanks.
2. Place samples in autosampler tray with a blank placed between each exhibit set.
3. Enter sample data into sequence table.
4. Run the calibration verification standards again at the end of the run.
5. Using the previously established calibration table, perform quantitative analysis on the blanks and samples. All values will be reported in the units of mg/kg.

4.7.6. Physical and Optical Data Interpretation

1. Experience and training of the Forensic Scientist shall be the primary criteria on which conclusions are based. These should be used as a guide to aid the forensic scientist in evaluating the data.
2. RI values reported by the GRIM3 system may vary ± 0.00010 at 589nm and ± 0.00020 at 656nm and 488nm within a single source.
3. Establish the mean, standard deviation (SD), and relative standard deviation ($RSD=100SD/mean$) for the known samples. Determine a three sigma RI range for the known samples by adding three times SD to the mean and subtracting three times SD from the mean. Establish the mean for the question samples. If the mean of the question samples falls within the range of the known, then the two are consistent. If the mean of the question samples falls outside the range of the known, then the two are inconsistent.



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4. Headlight glass should have an RI $n_D = 1.472 - 1.476$ using Dow Corning #550 silicone oil. The n_D value may vary ± 0.0008 in the same sample.
5. The n_D value in container glass may vary ± 0.0008 in the same sample.
6. Glass Wool should have a Refractive Index $n_D = 1.512 - 1.558$.
7. Slag Wool should have a Refractive Index $n_D = 1.5145 - 1.590$.
8. Rock Wool should have a Refractive Index n_D approximately 1.64. Rock Wool is soluble in 10% hydrochloric acid.

4.7.7. Elemental Data Interpretation

1. Using at least triplicate concentration values obtained during the analysis for each SRM and all samples, establish a mean concentration for each element.
2. Compare the determined mean concentrations for all the elements in the SRMs with concentration ranges established in the laboratory for each element. If the mean concentrations fall within the established ranges, then the analysis has performed properly.
3. Determine the standard deviation (SD) and relative standard deviation ($RSD=100SD/mean$) of the known samples for each element. If the RSD is less than 3%, convert 3 RSD to SD for that element. This is done to eliminate possible false exclusions when the RSD is very small.
4. Establish a four-sigma concentration range for each element of the known samples by subtracting four times SD from the mean and adding four times SD to the mean.
5. Compare concentration ranges of each element in the known glass samples to the mean concentration of each element in the question glass samples. If the concentrations of the question sample elements fall within the range of the known sample elements for **every** element, then the known and question are consistent. If the concentrations of the question sample elements do not fall within the range of the known sample elements for **any** element, then the known and question are inconsistent. In some glass samples not every element quantitated is present in the sample or is present at or below the limits



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of quantitation. These elements may be disregarded during comparison. Analyst training and experience will determine when this is necessary.

4.7.8. Controls

1. When using GRIM3, obtain refractive index of a certified reference glass (such as B7, $n_d=1.51462$) with each case prior to analysis of any evidence.
2. During elemental composition analysis, Standard Reference Material (SRM) #1831 (Soda-Lime Sheet Glass) and Standard Reference Material #612 (Trace Elements in a Glass Matrix, 50ppm) will be analyzed with each case. The data will be maintained in the case file.
3. A 50ppb solution of the second source Group I standard solution and a 5ppb solution of the second source Group II standard solution will be analyzed at the beginning and end of the analytical run as a calibration verification check. The calculated concentration for these samples will be within 20% of the known concentration.
4. At least one digestion blank, consisting of a blank tube and the three acids, must be prepared during the digestion and analyzed with the samples.
5. Blanks are run between calibration standards, SRMs, and each exhibit. Data from blanks and calibration checks will be maintained in the case file.

5. Measurement Traceability

Thermometers are certified traceable to NIST standards.
Pipettes are certified against NIST traceable standards.
Balances are certified against NIST traceable standards.
All single and multi-element standards are certified traceable to NIST Standard Reference Material.

6. Reference Materials

Locke Scientific Glass Reference Standards Set



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National Institute of Standards and Technology (NIST) Standard Reference Material (SRM) #1831 (Soda-Lime Sheet Glass)

NIST Standard Reference Material #612 (Trace Elements in a Glass Matrix, 50ppm)

7. Reports

The following are possible conclusions reached from the examination:

If the physical characteristics between the known and question samples are consistent, the optical characteristics are within the match criteria, and the elemental composition data are within the match criteria, then a definitive statement may be made that the known and question samples were the same and came from the same source or another source with identical physical and optical properties and elemental composition.

If the physical characteristics between the known and question samples are consistent and the optical characteristics are found to be within the match criteria, but no elemental compositional data can be obtained, then it may be stated that the known and question samples were consistent and could have come from the same source or another source with identical physical and optical properties.

If only optical characteristics from multiple wavelengths are obtained and found to be within the match criteria, then it may be stated that the question and known samples were consistent and could have come from the same source or another source with identical optical properties.

If only limited optical characteristics (e.g. only one wavelength and/or small number of edges measured) are obtained and are found to be within the match criteria, then it may be stated that the question sample cannot be eliminated as having come from the known source.

If any of the physical characteristics, elemental composition, or optical characteristics is not within the match criteria, then a statement may be made that the known and question samples were inconsistent and could not have come from the same source.

Variations to these interpretations may be made based upon the training and experience of the analyst or the types of glass received. These variations should be noted in case notes.

Report Wording

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Microscopic and instrumental analysis and comparison of the question exhibit with the known exhibit revealed them to be the same with respect to physical properties, optical properties, and elemental composition. These combined properties have been found to be highly discriminating among different sources of glass. Therefore, the question exhibit came from the known exhibit or another source of broken glass with identical physical and optical properties, and elemental composition. While coincidental associations of different sources of glass may exist, it is expected to be highly unusual.

Microscopic analysis and comparison of the question exhibit with the known exhibit revealed them to be consistent with respect to physical and optical properties. Therefore, the question exhibit could have come from the known exhibit or another source of broken glass with identical physical and optical properties.

Microscopic analysis and comparison of the question exhibit with the known exhibit revealed them to be consistent with respect to optical properties. Therefore, the question exhibit could have come from the known exhibit or another source of broken glass with identical optical properties.

Microscopic analysis of the question exhibit was limited due to the small amount of glass present (or small sample size). Comparison of the question exhibit with the known exhibit revealed that them to be consistent with respect to optical properties. Therefore, the question exhibit cannot be eliminated as having come from the known exhibit.

Microscopic (and instrumental) analysis and comparison of the question exhibit with the known exhibit revealed them to be inconsistent with respect to (list properties). Therefore, the question exhibit did not come from the known exhibit.

Examination of the question exhibit did not reveal the presence of glass for comparison to the known exhibit.

(If no known exhibit is submitted) Examination of the question exhibit revealed the presence of glass. Upon submission of a known glass exhibit, further analysis may be performed.