



Glass Analysis Test No. 15-548 Summary Report

This test was sent to 117 participants. Each participant received a sample set consisting of two sets of known glass fragments (Items 1 and 2) and one set of questioned glass particles (Item 3). Participants were requested to analyze and compare these and report their findings. Data were returned from 93 participants (79.5% response rate) and are compiled into the following tables:

	<u>Page</u>
<u>Manufacturer's Information</u>	<u>2</u>
<u>Summary Comments</u>	<u>3</u>
<u>Table 1: Examination Results</u>	<u>4</u>
<u>Table 2: Examination Procedures</u>	<u>6</u>
<u>Table 3: Conclusions</u>	<u>10</u>
<u>Table 4: Additional Comments</u>	<u>24</u>
<u>Appendix: Data Sheet</u>	<u>26</u>

This report contains the data received from the participants in this test. Since these participants are located in many countries around the world, and it is their option how the samples are to be used (e.g., training exercise, known or blind proficiency testing, research and development of new techniques, etc.), the results compiled in the Summary Report are not intended to be an overview of the quality of work performed in the profession and cannot be interpreted as such. The Summary Comments are included for the benefit of participants to assist with maintaining or enhancing the quality of their results. These comments are not intended to reflect the general state of the art within the profession.

Participant results are reported using a randomly assigned "WebCode". This code maintains participant's anonymity, provides linking of the various report sections, and will change with every report.

Manufacturer's Information

Each sample set consisted of three samples of glass fragments, two Known (Items 1 and 2) and one Questioned (Item 3). Items 2 and 3 were from the same picture frame glass, while Item 1 was from different picture frame glass. Examiners were instructed to examine the questioned glass particles and determine if any could have originated from the same source as the known recovered glass fragments (Items 1 and 2).

SAMPLE PREPARATION-

The glass from the two picture frames was wiped down, checked for defects, and the edges taped off to prevent the use of those areas. Differing items were processed and packaged separately from each other to prevent cross-contamination.

ITEM 1 (ELIMINATION): For the Known Item 1 samples, two glass fragments approximately 1/8" x 1/8" in size were selected and packaged in a glassine bag and then a pre-labeled Item 1 coin envelope. Item 1 was further packaged into the sample set as described below.

ITEMS 2 and 3 (IDENTIFICATION): For the Known Item 2 samples, two glass fragments approximately 1/8" x 1/8" in size were selected and packaged in a glassine bag and then a pre-labeled Item 2 coin envelope. For the questioned Item 3 samples, two glass particles approximately 1/16" x 1/16" in size were selected and packaged in a glassine bag and then a pre-labeled Item 3 coin envelope. Items 2 and 3 were taken in close spatial proximity to one another and were kept together as an identification group and packaged into the sample set as described below.

SAMPLE SET ASSEMBLY: For each sample set, an Item 2 and Item 3 from the same identification group were placed in a pre-labeled envelope along with an Item 1. The sample pack was sealed with invisible tape. Once verification was completed, all sample packs were further sealed with a piece of evidence tape and initialed "CTS".

The average refractive indices for the glass as reported by preliminary testing and predistribution laboratories are as follows: Item 1 RI = 1.51884, Item 2 RI = 1.51593, and Item 3 RI = 1.51591.

VERIFICATION: All three predistribution laboratories reported the expected association and elimination. The methods employed by the predistribution laboratories included Refractive Index (nD), UV fluorescence (long, short), thickness, color, physical match, glass type, and elemental analysis (solution ICP-MS).

**Revised: Item 1 average refractive index

Summary Comments

This test was designed to allow participants to assess their proficiency in the examination, comparison, and interpretation of glass samples. Each sample set consisted of three samples of glass, two Knowns (Items 1 and 2) and one Questioned (Item 3). Items 2 and 3 were from the same picture frame glass, while Item 1 was from different picture frame glass. Participants were requested to determine if the questioned particles could have come from either of the known sources. (Refer to the Manufacturer's Information for preparation details.)

Of the 93 participants that reported results, 91 (97.8%) reported that the Item 3 glass particles could have originated from the same source as the Item 2 known glass sample, but not the Item 1 known glass sample.

Of the remaining two participants, one concluded that Item 3 could not have originated from the same source as either Item 1 nor Item 2. The final participant concluded that Item 3 could have originated from the same source as the Item 1 known glass sample, but not the Item 2 known glass sample.

Examination Results

Could the questioned glass particles in Item 3 have originated from either of the picture frames as represented by Item 1 and Item 2, respectively?

TABLE 1

WebCode	Item 1	Item 2	WebCode	Item 1	Item 2
2DUR49	No	Yes	CXKQW9	No	Yes
33P8EK	No	Yes	CZTXY2	No	Yes
3BJAHH	No	Yes	D9H9M3	No	Yes
3EKFZ9	No	Yes	DJJHAR	No	Yes
4PDHEM	Yes	No	DMHRLE	No	Yes
4ZFNM3	No	Yes	DP7GLL	No	Yes
64ECPV	No	Yes	DWA3YV	No	Yes
6DKGD7	No	Yes	DWMUPQ	No	Yes
6EEZGT	No	Yes	DZ8LY9	No	Yes
6LTNFZ	No	Yes	E86XAV	No	Yes
6MMCWB	No	Yes	EDPUCK	No	Yes
73GLU2	No	Yes	EW73CZ	No	Yes
76ZFTM	No	Yes	EYAV8J	No	Yes
77VYXA	No	Yes	F7LAMU	No	Yes
77ZFV8	No	Yes	GDFWUK	No	Yes
7HBVUZ	No	Yes	GWDYUA	No	Yes
87RTV6	No	Yes	HLDQPX	No	Yes
8XD6WX	No	Yes	HTRW2U	No	Yes
9MBAER	No	Yes	J9WKRZ	No	Yes
9N6XU3	No	Yes	JCXLUH	No	Yes
9TJBXB	No	Yes	JEMTEF	No	Yes
A42A47	No	Yes	JHPXRZ	No	Yes
AAY86F	No	Yes	KE67HH	No	Yes
ABEH7T	No	Yes	KEG6A7	No	Yes
AQRWNQ	No	Yes	KRPLJW	No	Yes
AUCNX9	No	Yes	KWKFGX	No	Yes
AYMYP3	No	Yes	LA7A8H	No	Yes
CEBNZP	No	Yes	LCWD2P	No	Yes
CJ4TUU	No	Yes	LD6NTM	No	Yes
CKFMAU	No	Yes	LRFF9C	No	Yes
CM6TUQ	No	Yes	MHFZ9Z	No	Yes
CNCBQ2	No	Yes	NADFDH	No	Yes
CXKN86	No	Yes	NJ4RXB	No	Yes
			PR89YF	No	Yes

TABLE 1

WebCode	Item 1	Item 2	WebCode	Item 1	Item 2
PWMUT9	No	Yes			
Q399TY	No	Yes			
QFE2MW	No	Yes			
QJEDHW	No	Yes			
QRQJ99	No	Yes			
R4YWNZ	No	Yes			
REFJXZ	No	Yes			
RRKN38	No	Yes			
T29P7N	No	No			
T2NAT8	No	Yes			
T3HX9G	No	Yes			
T4EDLE	No	Yes			
TJTG89	No	Yes			
TMMDRT	No	Yes			
UHUVT9	No	Yes			
UKH63A	No	Yes			
UQL9T8	No	Yes			
UYELQL	No	Yes			
V2XX3W	No	Yes			
WMXFRP	No	Yes			
WQUDU2	No	Yes			
WT2KJ9	No	Yes			
XCWD68	No	Yes			
XMRLLN	No	Yes			
Y73XT6	No	Yes			
ZQ2LX7	No	Yes			

Response Summary			Total Participants: 93	
Could the questioned glass particles in Item 3 have originated from either of the picture frames as represented by Item 1 and Item 2, respectively?				
Response		<u>Item 1</u>	<u>Item 2</u>	
	Yes	1 (1.1%)	91 (97.8%)	
	No	92 (98.9%)	2 (2.2%)	
	Inconclusive	0 (0.0%)	0 (0.0%)	

Examination Procedures

TABLE 2

WebCode	Refractive Index				Color	Density	Thickness	Elemental		UV		
	nD	nF	nC	Δ RI				SEM/ EDS	XRS/ XRF	Long	Short	Other
2DUR49	✓				✓	✓	✓	✓		✓	✓	
33P8EK	✓						✓		✓	✓	✓	
3BJAHH	✓						✓		✓	✓	✓	
3EKFZ9	✓	✓	✓		✓	✓	✓			✓	✓	
4PDHEM	✓						✓		✓		✓	
4ZFN3				✓	✓		✓			✓	✓	
64ECPV	✓						✓	✓		✓	✓	
6DKGD7	✓			✓	✓		✓				✓	
6EEZGT							✓	✓				
6LTNFZ	✓				✓	✓	✓	✓			✓	
6MMCWB	✓	✓	✓		✓		✓			✓	✓	
73GLU2				✓	✓		✓		✓			
76ZFTM	✓				✓		✓	✓		✓	✓	
77VYXA	✓				✓		✓		✓	✓	✓	PLM
77ZV8	✓				✓	✓	✓		✓	✓	✓	
7HBVUZ	✓						✓					LA-ICP-MS Elemental Analysis
87RTV6	✓				✓		✓		✓		✓	
8XD6WX	✓				✓		✓					
9MBAER	✓											
9N6XU3	✓				✓		✓	✓		✓	✓	
9TJBXB	✓				✓		✓			✓	✓	LA-ICP-MS and LIBS
A42A47	✓						✓	✓		✓	✓	
AAY86F	✓			✓	✓		✓		✓		✓	
ABEH7T	✓				✓		✓				✓	Stereo microscopy
AQRWNQ	✓				✓		✓		✓	✓		
AUCNX9	✓				✓		✓			✓	✓	ICP-MS

TABLE 2

WebCode	Refractive Index				Color	Density	Thickness	Elemental		UV		
	nD	nF	nC	Δ RI				SEM/ EDS	XRS/ XRF	Long	Short	Other
AYMYP3	✓	✓	✓		✓	✓	✓			✓	✓	
CEBNZP	✓				✓		✓	✓		✓	✓	
CJ4TUU	✓						✓	✓		✓	✓	GRIM III
CKFMAU	✓				✓		✓				✓	ICP-OES
CM6TUQ	✓				✓		✓			✓	✓	
CNCBQ2	✓				✓		✓			✓	✓	
CXKN86	✓				✓		✓		✓		✓	
CXKQW9	✓				✓		✓		✓	✓	✓	
CZTXY2	✓				✓	✓	✓			✓	✓	
D9H9M3	✓				✓		✓			✓	✓	Solution ICP-MS
DJJHAR	✓				✓		✓	✓	✓	✓	✓	Laser-ICP-MS
DMHRLE	✓				✓		✓	✓		✓	✓	
DP7GLL	✓				✓		✓			✓	✓	
DWA3YV	✓						✓					LA-ICP-MS
DWMUPQ	✓				✓		✓		✓			
DZ8LY9				✓	✓		✓		✓	✓	✓	
E86XAV	✓				✓	✓	✓	✓		✓	✓	
EDPUCK	✓			✓	✓		✓			✓	✓	
EW73CZ	✓				✓		✓			✓	✓	physical match, glass type
EYAV8J	✓				✓	✓			✓	✓	✓	
F7LAMU	✓				✓	✓	✓	✓			✓	
GDFWUK	✓				✓			✓		✓	✓	
GWDYUA	✓				✓		✓	✓			✓	
HLDQPX	✓	✓	✓				✓		✓	✓	✓	
HTRW2U	✓				✓		✓			✓	✓	
J9WKRZ	✓				✓		✓		✓	✓	✓	
JCXLUH	✓						✓	✓			✓	

TABLE 2

WebCode	Refractive Index				Color	Density	Thickness	Elemental		UV		
	nD	nF	nC	ΔRI				SEM/ EDS	XRS/ XRF	Long	Short	Other
JEMTEF	✓			✓	✓			✓			✓	Interferometry (surface examination)
JHPXRZ	✓				✓		✓	✓	✓	✓	✓	
KE67HH	✓				✓		✓			✓	✓	
KEG6A7	✓			✓	✓		✓			✓	✓	LA-ICP-MS
KRPLJW	✓				✓		✓			✓	✓	
KWKFGX	✓			✓	✓		✓	✓			✓	
LA7A8H	✓				✓		✓			✓	✓	Elemental Analysis (XRF)
LCWD2P	✓				✓		✓					LA-ICPMS
LD6NTM	✓				✓		✓			✓	✓	
LRFF9C					✓		✓	✓				
MHFZ9Z	✓				✓	✓	✓		✓	✓	✓	
NADFDH	✓	✓			✓							
NJ4RXB				✓	✓		✓	✓				
PR89YF					✓		✓		✓			
PWMUT9												ICP-MS
Q399TY	✓						✓		✓			
QFE2MW	✓	✓	✓		✓	✓	✓			✓	✓	
QJEDHW	✓	✓	✓				✓			✓	✓	
QRQJ99	✓			✓	✓		✓				✓	
R4YWNZ	✓				✓		✓	✓				
REFJXZ	✓				✓		✓	✓			✓	
RRKN38						✓			✓			LIBS
T29P7N	✓	✓	✓		✓			✓				
T2NAT8					✓		✓		✓			LA-ICP/MS
T3HX9G	✓				✓	✓	✓			✓	✓	
T4EDLE	✓	✓	✓		✓	✓	✓				✓	

TABLE 2

WebCode	Refractive Index				Color	Density	Thickness	Elemental		UV		
	nD	nF	nC	Δ RI				SEM/ EDS	XRS/ XRF	Long	Short	Other
TJTG89	✓											
TMMDRT	✓				✓		✓		✓	✓	✓	
UHUVT9												Elemental Analysis LA-ICP-MS
UKH63A	✓				✓	✓	✓			✓	✓	LA-ICP-MS
UQL9T8	✓				✓		✓	✓		✓	✓	
UYELQL	✓				✓		✓		✓	✓	✓	
V2XX3W	✓						✓				✓	LA-ICP-MS
WMXFRP	✓				✓		✓		✓		✓	
WQUUDU2	✓				✓		✓				✓	LA-ICP-MS
WT2KJ9	✓						✓			✓	✓	
XCWD68	✓				✓		✓	✓		✓	✓	
XMRLLN	✓			✓	✓		✓		✓	✓	✓	
Y73XT6	✓				✓		✓				✓	
ZQ2LX7	✓				✓		✓			✓	✓	ICP-OES

Response Summary

Participants	Refractive Index				Color	Density	Thickness	Elemental		UV	
	nD	nF	nC	Δ RI				SEM/ EDS	XRS/ XRF	Long	Short
93	82	9	8	12	73	15	83	26	27	53	72
Percent	88%	10%	9%	13%	78%	16%	89%	28%	29%	57%	77%

Conclusions

TABLE 3

WebCode	Conclusions
2DUR49	Based on the particles examined, the glass from Item #3 was consistent with Item #2 glass in the physical properties examined, refractive index, and inorganic composition. It was concluded that these particles could have originated from the same source or another source of broken glass with the same properties. Glass recovered from Item #3 could not be associated with Item #1 glass due to differences in the physical properties examined, refractive index, and /or inorganic composition.
33P8EK	Glass fragments possess a unique array of properties, such as thickness, refractive index, color and elemental composition that can be examined and compared in an effort to associate questioned crime scene materials to a known source of origin. The refractive index of a transparent material is a measure of how much the speed of light is reduced inside the material and is the most commonly measured property in the forensic analysis of glass. Glass fragments can be chemically characterized based on the concentrations of certain elements present in the glass. Differences in manufacturer controlled elements or manufacturer uncontrolled trace elements may be used to compare glass fragments to known sources. Comparison of these physical, optical, and chemical properties involves the recognition and evaluation of characteristics that associate materials, but cannot provide an identification of a questioned sample to a known source to the exclusion of all others. Lab Item 1 (1) – FRAGMENTS OF GLASS FROM PICTURE FRAME #1. This item consisted of two fragments of glass. Lab Item 2 (2) – FRAGMENTS OF GLASS FROM PICTURE FRAME #2. This item consisted of two fragments of glass. Lab Item 3 (3) – FRAGMENTS OF GLASS FROM A BACKPACK. This item consisted of two fragments of glass. Both fragments were analyzed. The glass fragments from the backpack (lab item 3) differed from the glass from picture frame #1 (lab item 1) with respect to physical characteristics and elemental analysis. This is an elimination. The glass from the backpack (lab item 3) did not originate from the glass from picture frame #1 (lab item 1). The glass fragments from the backpack (lab item 3) are consistent with the glass from picture frame #2 (lab item 2) with respect to physical characteristics, elemental analysis, and refractive index. The glass fragments from the backpack (lab item 3) cannot be excluded from the submitted glass from picture frame #2 (lab item 2), therefore the glass fragments from the backpack (lab item 3) could have come from picture frame #2 (lab item 2) or other broken glass with the same physical, elemental, and optical properties. This is a Type III Association.
3BJAHH	CONCLUSIONS: The glass particles recovered from the suspect's backpack (item 1C) either originated from the second picture frame (item 1B) or another source of broken glass possessing the same distinct physical, optical, and chemical characteristics. The glass particles recovered from the suspect's backpack (item 1C) did not originate from the first picture frame (item 1A). RESULTS: The glass particles recovered from the suspect's backpack (item 1C) were examined for the purpose of determining whether or not they are like the known glass fragments from the picture frames (items 1A and 1B). The known glass fragments from the first picture frame (item 1A) are colorless non-tempered sheet float glass. The known glass fragments from the second picture frame (item 1B) are colorless non-tempered sheet glass. Examination and comparison of the questioned glass particles recovered from the suspect's backpack (item 1C) with the known glass standard from the second picture frame (item 1B) reveals they are alike with respect to physical, optical, and chemical characteristics. It is therefore concluded that these questioned glass particles recovered from the suspect's backpack (item 1C) either originated from the second picture frame (item 1B) or another source of broken glass possessing the same distinct physical, optical, and chemical characteristics. Examination and comparison of the questioned glass particles recovered from the suspect's backpack (item 1C) with the known glass standard from the first picture frame (item 1A) reveals they are dissimilar

TABLE 3

WebCode	Conclusions
	with respect to chemical characteristics. It is therefore concluded that these questioned glass particles recovered from the suspect's backpack (item 1C) did not originate from the first picture frame (item 1A). METHODS OF ANALYSIS: Examinations were performed visually, by stereo microscopy, polarized light microscopy, ultraviolet fluorescence, micrometry, refractive index determination, and x-ray fluorescence spectroscopy.
3EKFZ9	The glass in Item 3 did not originate from the same glass source as the glass in Item 1. The glass in Item 3 could have originated from the same glass source as the glass in Item 2.
4PDHEM	The findings provide support for the proposition that the recovered fragments in Item 3 originated from the known sample represented by Item 1, given the agreement in their physical and chemical properties. The glass fragments in Item 3 could not have originated from the source of the known fragments represented by Item 2 given the differences in refractive indices of the samples. (The strength of evidence is based on a verbal scale that can be used for both prosecution and defence propositions; inconclusive, slight support, support, strong support, very strong support)
4ZFNM3	The questioned glass recovered from the suspect's backpack (Item 3) was similar on the basis of color, thickness and refractive index in comparison to the known glass taken from the second picture frame (Item 2). In my opinion, the questioned glass Item 3 could have originated from the same source as known glass in Item 2.
64ECPV	1). The particles of questioned glass recovered from the cuff of the suspect's backpack (Item 3) were found to be distinguishable from the first picture frame (Item 1). This negative comparison indicates a different origin between both items. 2). The particles of questioned glass recovered from the cuff of the suspect's backpack (Item 3) could not be excluded as having come from the second picture frame (Item 2). Therefore, these glass particles came from either the second picture frame or from another source or sources of broken and clear glass indistinguishable from Item 3 in thickness, refractive index and elemental composition.
6DKGD7	Particles of questioned glass recovered from the suspect's backpack (Item 3) could have a common origin with glass fragments of known glass taken from the second picture frame (Item 2). Particles of questioned glass (Item 3) are different from glass fragments of known glass taken from the first picture frame (Item 1).
6EEZGT	Based on thickness measurements and SEM/EDS elemental composition data, Item #3 glass could have originated from Item #2 glass and not from Item #1 glass.
6LTNFZ	The following glass samples were examined: Item 1 Two fragments of known glass taken from the first picture frame. Item 2 Two fragments of known glass taken from the second picture frame. Item 3 Two particles of questioned glass recovered from the suspect's backpack. Analysis Result: The glass from the backpack of Item 3 has similar thickness, optical properties, physical properties and bulk chemical composition to the glass of Item 2. Therefore, the glass from the backpack could have come from the picture frame of Item 2. The glass from the backpack of Item 3 has different thickness, optical properties and physical properties than the glass of Item 1. Therefore, the glass from backpack did not come from the picture frame of Item 1. Analysis was performed using micrometer to measure glass thickness, refractive index measurements, density comparisons and scanning electron microscopy with energy dispersive x-ray spectroscopy. Trace elemental analysis could provide further discrimination of the glass samples. Trace elemental analysis on glass samples is not currently performed in this lab.
6MMCWB	The Item 2 known glass and the Item 3 questioned glass corresponded in general appearance, thickness, fluorescence, and refractive index (GRIM 3- 488nm, 656nm, and 488nm). Therefore, these two glasses could have come from a common source (Type 4 Association). It should be

TABLE 3

WebCode	Conclusions
	noted that the [Laboratory] currently does not have the instrumentation that would provide for additional discrimination which would allow for a higher association. It should also be noted that glass fragments can only originate from broken or damaged objects and not intact ones. The Item 1 known glass and the Item 3 questioned glass did not correspond in fluorescence and, therefore, can be eliminated as coming from a common source (Elimination). KEY for instrument acronyms: GRIM – Glass Refractive Index Measurement
73GLU2	The physical features of item #3 (thickness, color, refractive index and trace element concentrations) are identical to the features of item #2. The thickness and the trace elements concentrations are different in item #1 and item #2.
76ZFTM	Conclusions: I formed the opinion based on the techniques used, that the glass fragments recovered from the suspect's backpack Item 3, had a different refractive index to the control glass fragments collected from the first picture frame Item 1 and could not have originated from it. I also formed the opinion based on the techniques used, that the glass fragments recovered from the suspect's backpack Item 3, had the same appearance, refractive index and elemental composition to the control glass fragments collected from the second picture frame Item 2 and could have originated from it.
77VYXA	Analysis showed the glass from item #2 and item #3 was consistent in physical properties, refractive index, and elemental composition. These fragments could have shared a common origin. No association was found between the glass fragments in item #1 and item #3.
77ZEV8	The glass in Item 3 was identical to the glass in Item 2 in optical, physical, and elemental properties. This means that the questioned glass recovered from the suspect's backpack could have come from the second picture frame. The glass in Item 3 was different from the glass in Item 1. This means that the questioned glass recovered from the suspect's backpack did not come from the first picture frame.
7HBVUZ	Item #1 was examined using digital calipers. Items #2 and #3 were examined using digital calipers, automated glass refractive index measurement system (GRIM2) and laser ablation inductively coupled plasma mass spectrometry (ICP-MS). Items #1 and #3 were different in thickness of the glass; therefore, Item #3 did not originate from the same source as Item #1 (Elimination). Items #2 and #3 were consistent in thickness, refractive index and trace elemental composition; therefore, Item #3 could have originated from the same source as Item #2 (Level III Association). Terminology Key for Associative Evidence: The following descriptions are meant to provide context to the levels of opinions reached in this report. Every level of conclusion may not be applicable in every case nor for every material type. Level I Association: A positive identification; an association in which items share individual characteristics that show that the items were once from the same source. Level II Association: An association in which items are consistent in observed and measured physical properties and/or chemical composition and share atypical characteristic(s) that would not be expected to be readily available in the population of this evidence type. Level III Association: An association in which items are consistent in observed and measured physical properties and/or chemical composition and, therefore, could have originated from the same source. Because other items have been manufactured that would also be indistinguishable from the submitted evidence, an individual source cannot be determined. Level IV Association: An association in which items are consistent in observed and measured physical properties and/or chemical composition and, therefore, could have originated from the same source. As compared to a Level III association, items categorized within a Level IV share characteristics that are more common amongst these kinds of manufactured products. Alternatively, an association between items would be categorized as a Level IV if a limited analysis was performed due to characteristics or size of the specimen(s).

TABLE 3

WebCode	Conclusions
	<p>Level V Association: An association in which items are consistent in some, but not all, physical properties and/or chemical composition. Some minor variation(s) exists between the known and questioned items and could be due to factors such as sample heterogeneity, contamination of the sample(s), or having a sample of insufficient size to adequately assess homogeneity of the entity from which it was derived. Inconclusive: No conclusion could be reached regarding an association/elimination between the items. Elimination: The items were dissimilar in physical properties and/or chemical composition, indicating that they did not originate from the same source.</p>
87RTV6	<p>Questioned glass fragments (item 3) were compared to known glass fragments (item 2) using physical characteristics, refractive index measurements, and elemental analysis by X-Ray Fluorescence (XRF). The tested questioned glass fragments were similar in color, thickness, refractive index, and elemental composition to the known glass (item 2). The source of the known glass (item 2) is a possible source of the questioned glass fragments. Because similar glass has been manufactured that would be indistinguishable from the submitted evidence, an individual source cannot be determined. Questioned glass fragments (item 3) and known glass fragments (item 1) were compared using physical characteristics and elemental analysis by XRF. The tested questioned glass fragments (item 3) differed in elemental composition from the known glass (item 1). The questioned glass and the known glass (item 1) do not share a common origin.</p>
8XD6WX	<p>The questioned glass particles in item 3 have the same color, thickness and refractive index as the item 2. The questioned glass particles in item 3 have not the same thickness and refractive index as the item 1.</p>
9MBAER	<p>The questioned glass (item 3) recovered from the suspect's backpack originated from the known glass taken from the second picture frame (item 2). Item 3 did not originate from item 1 taken from first picture frame.</p>
9N6XU3	<p>The questioned glass in item 3 is consistent with the known glass in item 2 on the basis of color, thickness, luminescence, refractive index, and elemental composition. Therefore, the questioned glass in item 3 could have originated from the known glass in item 2. The questioned glass in item 3 is not consistent with the known glass in item 1 on the basis of thickness, luminescence, and refractive index.</p>
9TJBXB	<p>The glass recovered from the suspect's backpack, item 3, was indistinguishable in physical properties, refractive index, and elemental composition to the glass taken from the second picture frame, item 2. Therefore, the glass recovered from the suspect's backpack could have originated from the second picture frame or from another source of glass produced by the same manufacturer exhibiting the same physical and chemical properties. The glass recovered from the suspect's backpack, item 3, could not have originated from the glass of the first picture frame, item 1.</p>
A42A47	<p>1. Glass standard comprised of two clear, colorless glass fragments taken from the first picture frame; 2. Glass standard comprised of two clear, colorless glass fragments taken from the second picture frame; 3. Two small fragments of clear, colorless glass were found. The unknown glass recovered from the suspect's backpack either originated from the standard glass taken from the second picture frame (item #2) or from another source of broken glass possessing the same distinct physical and chemical characteristics. The unknown glass recovered from the suspect's backpack and the standard glass taken from the first picture frame (item #1) are not the same in physical and chemical characteristics. The unknown glass recovered from the suspect's backpack could not have originated from the standard glass taken from the first picture frame (item #1).</p>

TABLE 3

WebCode	Conclusions
AAY86F	The two glass particles, which were found in the backpack of the suspect (Item 3), matched the known glass Item 2 with respect to colour, thickness refractive index before an after an annealing procedure and elemental composition.[sic] Hence there is a serious clue that these two particles come from the second picture frame at the scene of crime. Due to the mass product character of glass tableware a different source cannot be excluded. Among a casework database, which consists of more than 3100 control glass items, there was no item, which matched the glass particles from the suspect in terms of all the properties, which were compared.
ABEH7T	The particles of questioned glass recovered from the suspect's backpack (Item 3) and the known glass from the second picture frame (Item 2) are not distinguishable in the examined criteria. The questioned glass (Item 3) and the known glass from the first picture frame (Item 1) have been found different in their refractive indices (nD).
AQRWNQ	The particles of questioned glass (Item3) recovered from the suspect's backpack are identical with the fragments of known glass taken from the second picture frame (Item2) in color, thickness, UV fluorescence, refractive index, elemental composition and Raman spectrum. However, the fragments of known glass taken from the first picture frame (Item1) are found to be different from Item3 in thickness, refractive index and elemental composition. Therefore, Item3 could have originated from the second picture frame, but not the first picture frame.
AUCNX9	Microscopic examination and analysis of item 1, known glass, in conjunction with item 3, questioned glass, revealed them to be different with respect to optical properties. Therefore, item 3 could not have come from the source represented by item 1. Microscopic examination and analysis and elemental analysis of item 2, known glass, in conjunction with item 3, questioned glass revealed them to be the same with respect to physical properties, optical properties, and elemental composition. Therefore, item 3 came from the source represented by item 2 or another source with identical physical and optical properties and elemental composition.
AYMYP3	The glass in Exhibit 3 could have originated from the same source as the glass in Exhibit 2. The glass in Exhibit 3 did not originate from the same source as the glass in Exhibit 1.
CEBNZP	The questioned glass particles in item (3) could have originated from the second picture frame (item 2) due to similarities in thickness, refractive index, and chemical composition.
CJ4TUU	The Item 3 glass sample/fragments/particle could not be associated with the Item 1 glass due to differences[sic] in physical properties and or refractive index. It was concluded that Item 3 glass sample/fragments/particle could have originated from the broken glass source represented by Item 2 or another source of broken glass with the same properties.
CKFMAU	Glass recovered from the suspect's backpack (Item 3) is indistinguishable in the observed and measured physical properties, refractive indices, and chemical concentrations from the glass from the second picture frame (Item 2). Accordingly, the glass recovered from the suspect's backpack (Item 3) either originated from the second picture frame (Item 2) or from another source of broken glass indistinguishable in all the observed and measured physical properties, refractive indices and chemical compositions. Glass recovered from the suspect's backpack (Item 3) is different from the glass from the first picture frame (Item 1). Accordingly, the first picture frame as represented by Item 1 is eliminated as a possible source of the glass recovered from the suspect's backpack (Item 3).
CM6TUQ	It was determined utilizing visual examination and measurement and Glass Refractive Index Measurement System(GRIM3), that the glass samples from item 1 and item 3 exhibit dissimilar

TABLE 3

WebCode	Conclusions
	thickness and refractive index. Therefore, based on those characteristics the known sample from item 1 can be eliminated as being the source of the questioned glass from item 3. It was determined utilizing visual examination and measurement and Glass Refractive Index Measurement System (GRIM3), that the glass samples from item 2 and item 3 exhibit consistent color, thickness and refractive index. Therefore, based on those characteristics the known sample from item 2 cannot be eliminated as being the source of the questioned glass from item 3.
CNCBQ2	The examined portions of the particles of questioned glass recovered from the suspect's backpack (item 1-3) were found to be different in physical and optical properties from the examined portion of the fragments of known glass taken from the first picture frame (item 1-1). Accordingly, the examined portions of the particles of questioned glass recovered from the suspect's backpack could not have originated from the examined portions of the fragments of known glass taken from the first picture frame. The examined portions of the particles of questioned glass recovered from the suspect's backpack (item 1-3) were found to be consistent in physical and optical properties with the examined portions of the fragments of known glass taken from the second picture frame (item 1-2). Accordingly, the examined portions of the particles of questioned glass recovered from the suspect's backpack could have originated from the examined portions of the fragments of known glass taken from the second picture frame or another source of glass with the same physical and optical properties.
CXKN86	Analysis and Conclusions: All the submitted particles are clear, colorless glass of an un-tempered variety. The questioned particles in Exhibit 3 were examined to determine whether they could have originated from either of the picture frames represented by Exhibits 1 and 2. Measurements were made of their thickness, elemental composition via X-ray Fluorescence Spectroscopy (XRF), and refractive index via GRIM3 (Glass Refractive Index Measurement Systems), and they were examined for evidence of flat glass manufacture using the float method. Exhibit 3 was differentiated from the standard in Exhibit 1 by both XRF and GRIM, as manufacture type. The picture frame represented by Exhibit 1 cannot be the source of the glass recovered from the suspect's property. Exhibit 3 was similar to the standard in Exhibit 2 in all measured properties and manufacture type. The picture frame represented by Exhibit 2, or another piece of broken glass sharing the same set of properties, could be the source of the glass recovered from the suspect's property.
CXKQW9	The glass in Item 3 was examined and compared to the glass in Item 1 and Item 2 for the purpose of determining if it could have originated from either of those sources. Item 1 consists of two full thickness fragments of colorless non-tempered float sheet glass. This glass was used as a standard represented as being from the first picture frame. Item 2 consists of two full thickness fragments of colorless non-tempered non-float sheet glass. This glass can be discriminated from the glass in Item 1 by its optical (refractive index and fluorescence) and chemical characteristics. This glass was used as a standard represented as being from the second picture frame. Item 3, represented as being recovered from the subject's backpack, consists of two full thickness fragments of colorless non-tempered non-float sheet glass. Microscopic and instrumental examination of these two fragments revealed that they are like the glass in Item 2 with respect to their thickness, optical and chemical characteristics. It is therefore concluded that the glass from the subject's backpack originated either from the second picture frame (Item 2) or from another source of broken colorless non-tempered non-float sheet glass having these same characteristics. The glass in Item 3 can be discriminated from the glass in Item 1 by its optical and chemical characteristics and therefore could not have originated from the first picture frame (Item 1).
CZTXY2	The colorless glass recovered from the backpack (item 3) was determined to be physically

TABLE 3

WebCode	Conclusions
	(density and thickness) and optically (refractive index) indistinguishable from the known colorless glass from second picture frame (item 2), and therefore they could have originated from the same source. The colorless glass from the backpack (item 3) was determined to be physically different from the colorless glass from the first picture frame (item 1).
D9H9M3	Microscopic and instrumental analysis and comparison of Item 3 with Item 1 revealed them to be inconsistent with respect to physical properties and refractive index. Therefore, Item 3 could not have come from the source of glass represented by Item 1. Microscopic and instrumental analysis and comparison of Item 3 with Item 2 revealed them to be the same with respect to physical properties, refractive index and elemental composition. Therefore, Item 3 came from the source of glass represented by Item 2 or another source of broken glass with identical physical properties, optical properties, and elemental composition.
DJJHAR	According to the results of above mentioned examination and analysis procedures, the questioned glass particles in Item 3 could have originated from the second picture frame as represented by Item 2, could not have originated from the first picture frame as represented by Item 1.
DMHRLE	No significant differences were detected between the glass samples in Item 2 and Item 3 in terms of appearance, physical properties (thickness & fluorescence), refractive index and elemental composition. Therefore, in my opinion, the glass" ...recovered from the suspect's backpack" Item 3 could have originated from "... the second picture frame" Item 2. Significant differences were detected in the thickness, fluorescent properties, refractive index and elemental composition between the glass samples Items 1 and Item 3. Therefore in my opinion, the glass" ... recovered from the suspect's backpack" Item 3 could not have originated from "...the first picture frame" Item 1.
DP7GLL	Examination and comparison of Items 1 and 3 revealed glass that was dissimilar in all measured optical properties. They could not have come from the same source. Examination and comparison of Items 2 and 3 revealed glass that was similar in all measured physical and optical properties. They could have come from the same source or any other source with the same properties.
DWA3YV	THE FRAGMENT OF KNOWN GLASS TAKEN FROM THE SECOND PICTURE FRAME "ITEM 2" AND TWO PARTICLES OF QUESTIONED GLASS RECOVERED[sic] FROM THE SUSPECT'S BACKPACK "ITEM 3" EXHIBIT THE SAME RESULTS IN ALL INVESTIGATED CHEMICAL COMPOSITION AND PHYSICAL PROPERTIES. BOTH OF THEM ARE SIGNIFICANTLY DIFFERENT FROM ITEM 1.
DWMUPQ	i. The refractive index of the questioned glass particles recovered from the suspect's backpack "Item 3" to be similar to the fragment of known glass 'Item 2'; ii. the refractive index of the questioned glass particles recovered from the suspect's backpack 'Item 3' to be dissimilar to the fragment of known glass 'Item 1'. Therefore, I am of the opinion that: i. The questioned glass particles 'Item 3' could have originated from the known glass 'Item 2'; ii. The questioned glass particles 'Item 3' did not originated from the known glass 'Item 1'.
DZ8LY9	Comparative examinations of Exhibit 2 (known glass taken from the second picture frame) with Exhibit 3 (particles of questioned glass recovered from the suspect's backpack) disclosed them to be consistent in physical characteristics, refractive indices, and elemental compositions. Therefore, Exhibit 3 could have originated from the glass in the second picture frame as represented by the glass fragment in Exhibit 2. Comparative examinations of Exhibit 1 (known glass taken from the first picture frame) with Exhibit 3 disclosed them to be different in thickness and elemental composition. Therefore, Exhibit 3 could not have originated from Exhibit 1.

TABLE 3

WebCode	Conclusions
E86XAV	the physical properties examined, refractive index, and inorganic composition. It was concluded that these particles could have originated from the same source or another source of broken glass with the same properties. Differences were noted between the glass from Item #3 and the glass from Item #1.
EDPUCK	The two glass fragments recovered from within the suspects backpack were found to be similar in colour, manufacturing process, thickness, refractive index and thermal history to the glass sample taken from Picture Frame 2, such that, in our opinion they could have had a common origin. Equally, the two glass fragments could have originated from a different source; however this alternative source would have to be recently broken and similar in colour, manufacturing process, thickness, refractive index and thermal history to the glass from Picture Frame 2.
EW73CZ	The glass from the suspect's backpack (Item 3) could have originated from the same source as the glass from the second picture frame (Item 2) or from another source with indistinguishable color, fluorescence, glass type, thickness, and refractive index. The glass from the suspect's backpack (Item 3) could not have originated from the same source as the glass from the first picture frame (Item 1).
EYAV8J	Visual, microscopic, density (sink-float) and instrumental analysis (EDXRF, GRIM III) of questioned glass particles QA and QB and comparison to the known glass particles K2A and K2B disclosed that they are consistent and no discriminating differences were observed with respect to color, density, elemental composition (EDXRF) and refractive index (GRIM III). Therefore, it is the opinion of the undersigned that questioned glass QA and QB submitted as lab item 3 could have originated from the same sources as the known glass K2A and K2B submitted as lab item 2 or another source exhibiting all of the same analyzed characteristics. Visual, microscopic, density (sink float) and instrumental analysis (EDXRF, GRIM III) of the questioned glass particles QA and QB and the known glass particles K1A and K1B disclosed that they are different with respect to their density, elemental composition (EDXRF) and refractive index (GRIM III). It is the opinion of the undersigned that the questioned glass QA and QB submitted as lab item 3 could not have come from the source represented by the known glass K1A and K1B submitted as lab item 1.
F7LAMU	Conclusions: Questioned glass (item 3), reportedly recovered from the suspect's backpack, was examined and subsequently found to be inconsistent with the known glass (item 1) reportedly from the first picture frame, regarding thickness and refractive index. Questioned glass (item 3), reportedly recovered from the suspect's backpack was examined and subsequently found to be consistent with the known glass (item 2) reportedly from the second picture frame, regarding color, thickness, density, gross elemental composition and refractive index. Based upon these observations, it is the opinion of this analyst that the questioned glass (item 3) could have a common origin with the known glass (item 2). It should be noted that other sources of glass with properties consistent with the above glass exist.
GDFWUK	It was found that item 2 could have originated from item 3. item 1 could not have originated from item 3.
GWDYUA	The glass located in the backpack #3 could not have originated from the picture frame #1. The glass located in the backpack #3 was indistinguishable from the picture frame glass #2 with respect to the analysis performed. Therefore the picture frame #2 could have been the source for the glass fragments located in the backpack.
HLDQPX	Examination of Exhibit 3 showed it to be dissimilar to Exhibit 1 in thickness and fluorescence; therefore, Exhibit 3 and Exhibit 1 did not originate from the same source. Examination of Exhibit 2 and Exhibit 3 showed that they were consistent in thickness, fluorescence, optical properties

TABLE 3

WebCode	Conclusions
	and elemental composition. Therefore, Exhibit 3 could have originated from the same sources as Exhibit 2 or another source with the same physical, optical and elemental properties.
HTRW2U	The questioned glass recovered from the suspect's backpack (Item 1-3) was examined microscopically and analyzed instrumentally and was different in optical and physical properties from the known glass taken from the first picture frame (Item 1-1). Accordingly, the questioned glass recovered from the suspect's backpack could not have originated from the known glass taken from the first picture frame. The questioned glass recovered from the suspect's backpack (Item 1-3) was examined microscopically and analyzed instrumentally and was consistent in optical and physical properties with the known glass taken from the second picture frame (Item 1-2). Accordingly, the questioned glass recovered from the suspect's backpack could have originated from the known glass taken from the second picture frame or another source of glass with the same optical and physical properties.
J9WKRZ	Comparative examinations of the questioned glass (Item 3) with the known glass (Item 1) revealed them to be inconsistent in their physical characteristics and elemental composition. Therefore, the glass in Item 3 could not have had a common origin with the glass represented in Item 1. Comparative examinations of the questioned glass (Item 3) with the known glass (Item 2) revealed them to be consistent in their physical characteristics, refractive indices, and elemental composition. Therefore, the glass in Item 3 could have had a common origin with the glass represented in Item 1.
JCXLUH	In my opinion: the fragments in the suspect's backpack could not have originated from item 1. the findings provide moderate support for the view that the fragments in the suspect's backpack originated from item 2
JEMTEF	In my opinion my findings provide moderately strong support for the proposition that the pieces of glass found in the backpack originated from the broken picture frame, item 2. In my opinion, my findings provide conclusive support that the glass from the backpack did not originate from the broken picture frame, item 1.
JHPXRZ	CONCLUSIONS: The two questioned glass fragments recovered from the suspect's backpack (CTS Item 3) did not originate from the first picture frame (CTS Item 1) The two questioned glass fragments recovered from the suspect's backpack (CTS Item 3) either originated from the second picture frame (CTS Item 2) or another source of broken glass possessing the same distinct physical, optical, and chemical characteristics. RESULTS: The two questioned glass fragments recovered from the suspect's backpack (CTS Item 3) were examined for the purpose of determining whether or not they are like the known glass standard from the first picture frame (CTS Item 1) and/or the known glass standard from the second picture frame (CTS Item 2). The two questioned glass fragments recovered from the suspect's backpack (CTS Item 3) were compared to the known glass standard from the first picture frame (CTS Item 1). Examination and comparison of these two questioned glass fragments recovered from the suspect's backpack (CTS Item 3) with the known glass standard from the first picture frame (CTS Item 1) reveals they are dissimilar with respect to chemical characteristics. It is therefore concluded that the two questioned glass fragments recovered from the suspect's backpack (CTS Item 3) did not originate from the first picture frame (CTS Item 1). The two questioned glass fragments recovered from the suspect's backpack (CTS Item 3) were compared to the known glass standard from the second picture frame (CTS Item 2). Examination and comparison of these two questioned glass fragments recovered from the suspect's backpack (CTS Item 3) with the known glass standard from the second picture frame (CTS Item 2) reveals they are alike with respect to physical, optical, and chemical characteristics. It is therefore concluded that the two questioned glass fragments recovered from the suspect's backpack (CTS Item 3) either originated from the

TABLE 3

WebCode	Conclusions
	second picture frame (CTS Item 2) or another source of broken glass possessing the same distinct physical, optical, and chemical characteristics. METHODS OF ANALYSIS: Examinations were performed visually, by stereo microscopy, polarized light microscopy, ultraviolet fluorescence, micrometry, refractive index determination, scanning electron microscopy/energy dispersive x-ray spectroscopy, and x-ray fluorescence spectroscopy.
KE67HH	The glass from questioned "Item 3" was found to be consistent with the known glass "Item 2" and inconsistent with the known glass "Item 1". Therefore the glass from the "Item 3" could have come from the same source as the glass from "Item 2".
KEG6A7	The two glass pieces recovered from the suspect's backpack (item 3) could not be excluded as having come from the broken second picture frame (item 2). Therefore, these two glass pieces came from either the broken second picture frame or from another source or sources of broken, clear, colourless, annealed, non-float glass indistinguishable from item 2 in thickness, refractive index and elemental composition. The two glass pieces recovered from the suspect's backpack (item 3) did not come from the broken first picture frame (item 1).
KRPLJW	Glass particles from the suspect's backpack (Item 3) are similar in physical and optical properties to the known glass fragments from the second picture frame (Item 2). It is our opinion that the particles from the backpack could have come from the second picture frame. However, we are currently unable to compare the trace element composition of the two items. Therefore, this is a limited comparison. (Category 2C) Glass particles from the suspect's backpack (Item 3) exhibit different physical and optical properties from the glass fragments from the first picture frame (Item 1). It is our opinion that the glass particles from the backpack did not come from the first picture frame. (Category 5)
KWKFGX	The results of the examination give support for the hypothesis that the analysed glass particle in Item 3 originates from the picture frame as represented by Item 2 (Level +2). The results of the examination give extremely strong support for the hypothesis that the analysed glass particle in Item 3 does not originate from the picture frame as represented by Item 1 (Level -4).
LA7A8H	Based on our examination the questioned glass particles recovered from the suspect's backpack (Item 3) could not be differentiated from the material of comparison of the second picture frame (Item 2). They could therefore have a common source. The first picture frame (Item 1) could be clearly distinguished from the questioned glass particles (Item 3) and could be excluded as being the origin of the questioned particles.
LCWD2P	The particles of questioned glass recovered from the suspect's backpack (Item 3) differ in refractive index and in chemical composition from the known glass taken from the first picture frame (Item 1). Therefore the particles of questioned glass (Item 3) could not have originated from the first picture frame (Item 1). The particles of questioned glass recovered from the suspect's backpack (Item 3) are similar in refractive index and in chemical composition, compared with the known glass taken from the second picture frame (Item 2). These results are much more likely if the questioned glass particles (Item 3) have originated from the second picture frame (Item 2), than if they have originated from a random other glass object.
LD6NTM	Glass recovered from the suspect's backpack (Item 3) is similar in color, thickness, optical properties, and refractive index to the known glass from the second picture frame (Item 2). It is our opinion that the glass recovered from the suspect's backpack (Item 3) and the known glass from the second picture frame (Item 2) could have come from the same source. Please note that elemental analysis was not performed on these samples due to instrument maintenance. Glass from the suspect's backpack (Item 3) is dissimilar to the known glass from the first picture frame (Item 1). It is our opinion that the glass from the suspect's backpack and the known glass

TABLE 3

WebCode	Conclusions
	from the first picture frame did not come from the same source.
LRFF9C	The questioned glass fragments from item 3 could not have originated from item 1. The questioned glass fragments from item 3 could have originated from item 2. The questioned glass fragments recovered from the suspect's backpack could have originated from the second broken picture frame.
MHFZ9Z	The glass in Item 3 is identical to the glass in Item 2 in optical, physical, and elemental properties. This means the glass recovered from the suspect's backpack could have come from the second picture frame. The glass in Item 3 is different from the glass in Item 1. This means the glass recovered from the suspect's backpack did not come from the first picture frame.
NADFDH	1. The two particles of questioned glass (item 3), recovered from the suspect's backpack, and the two fragments originated from the two fragments of known glass (item 2), taken from the second picture, conformed in their refractive indices and color. It could not be excluded that the two particles recovered from the suspect's backpack (item 3) and the fragments originated from the known glass (item 2) were from a single glass pane. 2. The two particles of questioned glass (item 3), recovered from the suspect's backpack, and the two fragments originated from the two fragments of known glass (item 1), taken from the first picture, did not conform in their refractive indices. [sic]
NJ4RXB	Based on our findings, we conclude that Items 3 and Items 2 by a high degree of certainty are of similar type, as they were indistinguishable by means of thickness, refractive index and elemental composition. We can not confirm whether or not Items 2 and Items 3 share common origin. Items 1 and Items 3 do not share common origin.
PR89YF	Light Microscopy examination indicated that Sample 2 and 3 had the same thickness. X-ray microfluorescence[sic] analysis demonstrated that Samples 2 and 3 had the same elemental composition and were likely to have originated from the same/a similar source. Sample 1 is considered to have originated from a separate source.
PWMUT9	Items 1, 2, and 3 were analyzed using Inductively Coupled Plasma Mass Spectrometry (ICP-MS). Based on the results for selected elements, Items 1 and 3 have distinguishable elemental profiles and therefore could not have originated from the same source. Based on the results for the selected elements, Items 2 and 3 were not distinguishable and therefore could have originated from the same source.
Q399TY	Based on elemental analysis Item 3 can be differentiated from Item 1. Therefore, the glass recovered from Item 3 could not have come from Item 1. Based on RI and elemental analysis Item 3 can not be differentiated from Item 2. Therefore, the glass recovered from Item 3 could have come from Item 2 or from another source that is physically and elementally similar.
QFE2MW	Item 3 could have originated from the same source as Item 2. Item 3 and Item 1 did not originate from the same source.
QJEDHW	The glass in Item 3 is similar in thickness and refractive index to the glass in Item 2; therefore, these glass fragments could have originated from the same source. The glass in Item 3 is dissimilar in refractive index to the glass in Item 1; therefore, these glass fragments did not originate from the same source.
QRQJ99	The glass recovered from the suspect's backpack matched the glass that comprised the second picture frame, by the applied laboratory tests. The glass recovered from the suspect's backpack could NOT have originated from the first picture frame.
R4YWNZ	Each of the known glass fragments in Item 1 and Item 2 taken from the first and second picture

TABLE 3

WebCode	Conclusions
	<p>frame respectively was a transparent and colourless glass fragment. Upon examination, the known glass fragments from Item 1 were found to agree in colour, but differ in thickness, refractive index and elemental composition with those from Item 2. The questioned glass sample in Item 3 recovered from the suspect's backpack comprised two pieces of transparent and colourless glass fragments. These recovered glass fragments were found to agree in colour, thickness, refractive index and elemental composition with the known glass sample Item 2, suggesting that they could have come from the same source. The questioned glass sample in Item #3 were found to agree in colour, but differ in thickness, refractive index and elemental composition with the known glass sample item 1, suggesting that they did not share a common origin.</p>
REFJXZ	<p>The glass from the first and second picture frames were found to have different thicknesses and were therefore able to be differentiated from each other based on this property. In relation to colour, thickness, refractive index and elemental composition, the glass recovered from the backpack (item 3) was found to be indistinguishable from the glass collected from the second picture frame (item 2). These items may therefore share a common origin.</p>
RRKN38	<p>The density measurement of item 3 yielded a density of 2.4865 g/cm³ which matches the density of item 2. The density of item 1 is 2.4963 g/cm³ and therefore does not match with any of the two other samples. The analysis of the chemical composition by LIBS and XRF also show that item 2 and 3 match. The results are within measurement inaccuracy.</p>
T29P7N	<p>Items 1-3 were examined instrumentally using the Emmons Double Variation method to determine refractive index values and with Scanning Electron Microscopy/Energy Dispersive Spectroscopy for elemental profiles. Item 3 (questioned glass) was not consistent to items 1 and 2 with respect to measured refractive index values. Therefore, item 3 could not have originated from the known items as represented by samples submitted as 1 and 2.</p>
T2NAT8	<p>The glass fragments from the suspect's backpack (Item 3) were indistinguishable in the properties examined from the know[sic] glass Item2 and therefore may have originated from the same source.</p>
T3HX9G	<p>Items 1, 2 and 3 were examined using a digital caliper, ultraviolet light and the Glass Refractive Index Measurement system (GRIM3). Items 2 and 3 were also examined using a density comparison technique. The Items 1 and 2 glass samples could be distinguished from each other based upon differences in float properties and refractive index. The Item 3 glass particles were consistent with the Item 2 glass in color, thickness, temper, float properties, density and refractive index. It was concluded that these Item 3 particles could have originated from the broken glass source represented by Item 2 or another source of broken glass with the same properties. The Item 3 glass particles could not be associated with the Item 1 glass due to differences in float properties and refractive index.</p>
T4EDLE	<p>The glass in Item #3 is similar in color and thickness and dissimilar in UV fluorescence, density, and refractive index to the glass in Item #1. The glass in Item #3 did not originate from the same source as the glass in Item #1. The glass in Item #3 is similar in color, UV fluorescence, thickness, density and refractive index to the glass in Item #2. The glass in Item #3 could have originated from the same source as the glass in Item #2.</p>
TJTG89	<p>1. The fragments of questioned glass recovered from the suspect's backpack (Item 3) did not originate from the fragments of glass taken from the first picture frame (Item 1); 2. The fragments of questioned glass recovered from the suspect's backpack (Item 3) had similar physical characteristics as the fragments of glass taken from the second picture frame (Item 2) and could have originated from Item 2</p>

TABLE 3

WebCode	Conclusions
TMMDRT	first picture frame) with the glass fragments in Exhibit 3 (questioned glass recovered from the suspect's backpack) disclosed them to be dissimilar in their physical characteristics and elemental composition. Therefore, the glass fragments in Exhibits 1 and 3 do not share a common source of origin; 2. Comparative examinations of the glass fragments in Exhibit 2 (known glass taken from the second picture frame) with the glass fragments in Exhibit 3 (questioned glass recovered from the suspect's backpack) disclosed them to be indistinguishable in their physical characteristics, elemental compositions, and refractive indices. Therefore, the glass fragments in Exhibits 2 and 3 could have had a common source of origin.
UHVUT9	As a result of my examination I determined that: 1.1 The chemical composition of the glass fragments of "Item1" and the chemical composition of the glass fragments of "Item3" are distinguishable; 1.2 The glass fragments "Item1" and "Item3" could therefore not have the same origin; 1.3 The chemical composition of the glass fragments of "Item2" and the chemical composition of the glass fragments of "Item3" are indistinguishable; 1.4 The glass fragments of "Item2" and "Item3" could therefore have the same origin.
UKH63A	The glass fragments from Item 3 were found likely to have originated from the same source as the control glass fragments from Item 2, or another source of glass with similar characteristics. The glass fragments from Item 3 did not originate from the same source as the control glass fragments from Item 1.
UQL9T8	The glass fragments associated with the two controls (1) + (2) were distinguishable by RI and thickness. The glass fragments associated with item (3) were indistinguishable by RI, thickness and elemental composition, from the glass control sample(2). Hence in my opinion the glass fragments recovered from the suspects back pack, could have originated from the second picture frame.
UYELQL	No association was found between the known glass taken from the first picture frame (item #1) and the broken glass recovered from the suspect's backpack (item #3). Analysis showed the known glass taken from the second picture frame (item #2) and the broken glass recovered from the suspect's backpack (item #3) were consistent in physical properties, refractive index, and elemental composition. These fragments could have shared a common origin.
V2XX3W	Item 1 comprised two fragments of colourless annealed float glass, with an average thickness of 1.78mm and an average RI of 1.5188. Item 2 comprised two fragments of colourless annealed non-float glass, with an average thickness of 1.84mm and an average RI of 1.5158. Item 3 comprised two fragments of colourless annealed non-float glass, with an average thickness of 1.83mm and an average RI of 1.5158. Item 3 corresponded in colour, thickness, average refractive index and trace elemental concentrations to the control glass, Item 2. These results strongly support the proposition that the glass recovered from the suspect's backpack (Item 3) originated from the second picture frame (Item 2). The frequency of glass indistinguishable from Item 2 is unknown.
WMXFRP	The glass in Item 3 and the glass in Item 2 were found to be alike in all measured characteristics. Therefore, the glass in Item 2 and the glass in Item 3 may share a common origin. The glass in Item 1 were found to be dissimilar to the glass in Item 3.
WQUDU2	The two glass particles recovered from the suspect's backpack can originate from the second picture frame. There are significant differences concerning nD, UV fluorescence and elemental composition between the glass of the two picture frames. The difference in thickness is also sufficient to distinguish between them.
WT2KJ9	Item 1 is not consistent with item 3. Item 2 is consistent with item 3 as long as refractive index and thickness respects nevertheless their elemental compositions could make a difference.

TABLE 3

WebCode	Conclusions
XCWD68	<p>The glass recovered from picture frame #2 (Item 2) and the glass recovered from the suspect's backpack (Item 3) are consistent based on refractive index (GRIM3), optical properties (Polarized Light Microscopy) and elemental characteristics (Scanning Electron Microscopy with Energy Dispersive X-ray Spectroscopy). Therefore, the glass recovered from picture frame #2 (Item 2) and the glass recovered the suspect's backpack (Item 3) could share a common source of origin. The glass recovered from picture frame #1 (Item 1) and the glass recovered from the suspect's backpack (Item 3) are not consistent in refractive index (GRIM3) and elemental characteristics (Scanning Electron Microscopy with Energy Dispersive X-ray Spectroscopy). The glass recovered from the suspect's backpack (Item 3) could not share a common origin with the glass recovered from picture frame #1 (Item 1).</p>
XMRLLN	<p>1. Examinations of the glass particles in Item 3 (questioned glass particles recovered from the suspect's backpack) disclosed them to be consistent with the glass fragments in Item 2 (known glass fragments taken from the second picture frame) in their physical characteristics, elemental composition, refractive index, and thermal characteristics. As a result of these findings, the glass particles in Item 3 could have originated from the picture frame as represented by Item 2; 2. Examinations of the glass particles in Item 3 disclosed them to be dissimilar to the glass fragments in Item 1 (known glass fragments taken from the first picture frame) in their elemental composition. As a result of this finding, the glass particles in Item 3 could not have originated from the picture frame as represented by Item 1.</p>
Y73XT6	<p>Analysis of the fragments of glass in item 3 (glass recovered from the backpack) and item 2 (glass from the second picture frame) showed that they were indistinguishable from each other in terms of thickness, refractive index, thermal history and surface characteristics[sic], Item 1 (glass from first picture frame) was distinguishable from items 2+3 in terms of refractive index. It is not possible to determine if the glass sample in item 3 originated from the source represented by item 2 however it must be noted that if the glass in item 3 originated from an alternative source or sources these would have to match the control glass item 2 in terms of thickness, refractive index, thermal history and surface characteristics[sic].</p>
ZQ2LX7	<p>Glass recovered from the backpack (Item 3) is indistinguishable in the observed and measured physical properties, refractive indices, and chemical composition from the glass recovered from the second picture frame as represented by Item 2. Therefore, the glass fragments recovered from the backpack (Item 3) either originated from the second picture frame as represented by Item 2 or from another source of broken glass indistinguishable in all the observed and measured physical properties, refractive indices, and chemical composition. Glass recovered from the backpack (Item 3) is different than the glass from the first picture frame as represented by Item 1. Therefore the glass from the first picture frame as represented by Item 1 is eliminated as a possible source of the glass recovered from the backpack (Item 3).</p>

Additional Comments

TABLE 4

WebCode	Additional Comments
3EKFZ9	Conclusions are based solely on the following observed/measured properties: color, glass type, UV fluorescence properties, thickness, density, and refractive index. Elemental analysis was not performed, because it is not part of this laboratory's standard analysis procedure for glass comparisons.
64ECPV	The refractive index was measured with a Glass Refractive Index Measurement 3 (GRIM3, Foster and Freeman) system. And the elemental analysis was measured with a SEM/EDS (Jeol Mod. LV6610 / EDS Oxford).
76ZFTM	All fragments submitted were found to possess original edges albeit partial in some fragments. Thickness measurements using either a calibrated eye piece graticule or calibrated vernier calipers were hampered by the physical position of the original edges which were often offset hence, discrimination based on thickness measurements was found to be unreliable. Each fragment was found to be approximately 2mm thick.
ABEH7T	The examination methods "Refractive index measurement" and "Preparation of glass fragments for GRIM 3 measurement" are accredited according to ISO 17025.
CKFMAU	The conclusions stated above would not stand on their own. Included with every report is a section on methods used, association criterion, interpretation, limitations and additional remarks. This information is critical to the correct evaluation of the conclusion statements and the weight of the evidence. These sections cannot be included in this form because the text box is insufficient.
CM6TUQ	At the present time the examiner lacks the capabilities to conduct elemental analysis.
CXKN86	Our normal procedures for establishing statistical ranges for refractive index and elemental composition cannot be used when each known sample has only two fragments. Please consider sending more fragments to more closely approach the normal variation observed in broken glass objects.
DWA3YV	STATISTICAL TREATMENT: ON THE ONE HAND, T-TEST FOR THICKNESS AND REFRACTION INDEX. ON THE OTHER HAND, 4SD (PREVIOUS MINIMUM[sic] 3% RSD FILTERED) FOR LA-ICP-MS RESULTS
GWDYUA	Glass refractive indices[sic] are not unique and other sources for the glass in the backpack can not be excluded. SEM/EDX is not routinely undertaken by the laboratory.
HTRW2U	Unable to electronically submit results using Mozilla or Internet Explorer 11.
JEMTEF	In my opinion, based on my assessment of the information available to me including my experience and my inspection of a limited dataset of glass samples previously analysed in the laboratory, I consider this glass to be one of the less commonly encountered types. It should be borne in mind that the database used is predominantly window glass, with relatively few samples from picture frames. Therefore, a cautious approach was used when considering this finding. Interferometry, a microscopic technique used to examine the surfaces of glass, was used to examine the samples from item 3, which were found to originate from a non-float source with similar characteristics to the glass from item 2. These characteristics are not what I would have expected from window or container glass. It should be noted that I cannot say how the glass was acquired. Glass may be retained inside a backpack compartment almost indefinitely and, therefore, I cannot say when they were acquired either.
JHPXRZ	More than two fragments of known glass would be helpful to better categorize the known glass and establish a range for thickness measurements.
KEG6A7	Annealed, non-float glass that is indistinguishable from the broken second picture frame (item

TABLE 4

WebCode	Additional Comments
	2) in thickness and refractive index has not previously been encountered in the 2350 samples of broken glass collected from case work and survey samples and examined at this laboratory, for which thermal history, float glass data, thickness and refractive index are available. Elemental Analysis of glass by LA-ICP-MS provides additional discrimination between sources. In this case, the concentrations of 21 elements were analyzed and used for comparison.
LA7A8H	The content of Al, K, Ca and Fe of Item 1 (material of comparison of first picture frame) was significantly different from Item 3 (questioned particles) and Item 2 (material of comparison of second picture frame). There elemental analysis (XRF) confirmed our GRIM results regarding the RI.
T2NAT8	The glass fragments in Item 1 and Item 3 were found to be different in elemental composition and could not have originated from the same source.
UKH63A	Refractive index: Item 1: 1.5188 - 1.5189, Item 2: 1.5159 - 1.5160, Item 3: 1.5159 - 1.5160. Comparison of trace elemental compositions: The match criterion for LA-ICP-MS analysis was set at 4SD range (minimum 3% RSD) around control sample. The elements compared are: Li7, Na23, Mg24, Al27, K39, Ca42, Ti49, Mn55, Fe57, Rb85, Sr88, Zr90, Ba137, La139, Ce140, Nd146, Hf178, Pb208. Comparing Item 1 and Item 3, the concentrations of the following elements are different: Li7, Al27, K39, Ca42, Ti49, Mn55, Fe57, Rb85, Sr88, Zr90, Ba137, La139, Ce140, Nd146, Hf178, Pb208.
V2XX3W	Non-float glasses may present non-uniform thickness. Trace elemental concentrations of selected elements determined using laser ablation ICP-MS.
ZQ2LX7	In addition to our conclusions, we also have "Methods", "Interpretation", "Limitations" and "Remarks" sections in our reports. The "Interpretation" section includes guidance as to the weight of the evidence which is critical for understanding the conclusions. The stand-alone conclusions required by the size of the CTS text box are inadequate to convey this.

Appendix: Data Sheet

Collaborative Testing Services ~ Forensic Testing Program

Test No. 15-548: Glass Analysis

DATA MUST BE RECEIVED BY August 03, 2015 TO BE INCLUDED IN THE REPORT

Participant Code:

WebCode:

Accreditation Release Statement

CTS submits external proficiency test data directly to ASCLD/LAB and ANAB. Please select one of the following statements to ensure your data is handled appropriately.

☐ This participant's data is intended for submission to ASCLD/LAB and/or ANAB.
(Accreditation Release section on the last page must be completed and submitted.)

☐ This participant's data is NOT intended for submission to ASCLD/LAB or ANAB.

Online Data Entry

Visit www.cts-portal.com to enter your proficiency test results online. If you have any questions please do not hesitate to contact CTS.

Scenario:

Police are investigating vandalism that occurred at a model home during the night. Among the damage were two picture frames with broken glass. Known samples were taken from the glass remaining in the picture frames. The police apprehended a suspect and found shards of glass in his backpack. Investigators are requesting that you examine and compare the glass particles recovered from the suspect with the fragments recovered from the two broken picture frames.

Please Note:

-Samples contained within each individual Item are from a single source.

-CTS will not reproduce Interpretation Scales, Scale of Conclusions or Terminology Keys in the final report, please do not submit with the participant's data sheet.

Items Submitted (Sample Pack GL):

Item 1: Two fragments of known glass taken from the first picture frame.

Item 2: Two fragments of known glass taken from the second picture frame.

Item 3: Two particles of questioned glass recovered from the suspect's backpack.

1.) Could the questioned glass particles in Item 3 have originated from either of the picture frames as represented by Item 1 and Item 2, respectively?

Item 1: Yes ☐ No ☐ Inconclusive ☐

Item 2: Yes ☐ No ☐ Inconclusive ☐

Please return all pages of this data sheet.

Page 1 of 3

Participant Code:

WebCode:

2.) Indicate the procedures used to examine the submitted items:

Refractive Index:

☐ nD☐ nC☐ nF☐ Δ RI

UV Fluorescence:

☐ Long☐ Short☐ Color☐ Thickness☐ Density

Elemental Analysis:

☐ SEM/EDS☐ XRS/XRF☐ Other (specify): _____**3.) What would be the wording of the Conclusions in your report?**

4.) Additional Comments

Return Instructions: Data must be received via online data entry, fax (please include a cover sheet), or mail by **August 03, 2015** to be included in the report.

QUESTIONS?

TEL: +1-571-434-1925 (8 am - 4:30 pm EST)

EMAIL: forensics@cts-interlab.comwww.ctsforensics.com

Participant Code:

ONLINE DATA ENTRY: www.cts-portal.com

FAX: +1-571-434-1937

or Toll-Free: 1-866-FAX-2CTS (329-2287)

MAIL: Collaborative Testing Services, Inc.

P.O. Box 650820

Sterling, VA 20165-0820 USA

Please return all pages of this data sheet.

Page 2 of 3

Collaborative Testing Services ~ Forensic Testing Program

RELEASE OF DATA TO ACCREDITATION BODIES

The following Accreditation Releases will apply only to:

Participant Code:

WebCode:

for Test No. **15-548: Glass Analysis**

This release page must be completed and received by **August 3, 2015** to have this participant's submitted data included in the reports forwarded to the respective Accreditation Bodies.

ASCLD/LAB RELEASE

If your lab has been accredited by ASCLD/LAB and you are submitting this data as part of their external proficiency test requirements, have the laboratory's designated individual complete the following.

The information below must be completed in its entirety for the results to be submitted to ASCLD/LAB.

ASCLD/LAB Legacy Certificate No. _____ ASCLD/LAB International Certificate No. _____

Signature _____ Date _____

Laboratory Name _____

Location (City/State) _____

ANAB RELEASE

If your laboratory maintains its accreditation through ANAB, please complete the following form in its entirety to have your results forwarded.

ANAB Certificate No. _____

Signature and Title _____ Date _____

Laboratory Name _____

Location (City/State) _____

Accreditation Release**Return Instructions**

Please submit the completed Accreditation Release at the same time as your full data sheet. See Data Sheet Return Instructions on the previous page.

Questions? Contact us 8 am-4:30 pm EST

Telephone: +1-571-434-1925

email: forensics@cts-interlab.com

Please return all pages of this data sheet.

Page 3 of 3