



## **Glass Analysis Test No. 19-548 Summary Report**

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Each participant received a sample set consisting of one set of known glass fragments (Item 1) and two sets of questioned glass particles (Items 2 and 3). Participants were requested to analyze and compare these and report their findings. Data were returned from 75 participants and are compiled into the following tables:

	<u>Page</u>
<a href="#"><u>Manufacturer's Information</u></a>	<u>2</u>
<a href="#"><u>Summary Comments</u></a>	<u>3</u>
<a href="#"><u>Table 1: Examination Results</u></a>	<u>4</u>
<a href="#"><u>Table 2: Examination Procedures</u></a>	<u>6</u>
<a href="#"><u>Table 3: Conclusions</u></a>	<u>9</u>
<a href="#"><u>Table 4: Additional Comments</u></a>	<u>22</u>
<a href="#"><u>Appendix: Data Sheet</u></a>	

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, one Known (Item 1) and two Questioned (Items 2 & 3). Items 1 and 3 were from the same window pane glass, while Item 2 was from an outdoor lamp glass. Examiners were instructed to examine the questioned glass particles and determine if they could have originated from the Known recovered glass fragments (Item 1).

## **SAMPLE PREPARATION-**

The glass was examined for defects and then broken. Differing items were processed and packaged separately from each other to prevent cross-contamination.

ITEMS 1 and 3 (ASSOCIATION): 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. 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 1 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.

ITEM 2 (ELIMINATION): For the Questioned Item 2 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 2 coin envelope. Item 2 was further packaged into the sample set as described below.

SAMPLE SET ASSEMBLY: For each sample set, an Item 1 and Item 3 from the same association group were placed in a pre-labeled envelope along with an Item 2. 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 = 1.51919, Item 2 RI = 1.51698, and Item 3 RI = 1.51898 .

VERIFICATION: All three predistribution laboratories reported the expected association and elimination. The methods employed by the predistribution laboratories included refractive index nD, UV fluorescence short and long, color, thickness, and XRS/XRF.

## **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, one known (Item 1) and two questioned (Items 2 and 3). Items 1 and 3 were from the same piece of window glass, while Item 2 was from a different piece of lamp glass. Participants were requested to determine if either set of questioned particles could have come from the known source. (Refer to the Manufacturer's Information for preparation details.)

Of the 75 participants that reported results, 74 (98.7%) reported that the Item 3 glass particles could have originated from the Item 1 known glass sample and the Item 2 glass particles could not have originated from the Item 1 known glass sample. The remaining participant reported that Item 2 could have originated from Item 1 and Item 3 could not have originated from the Item 1 known glass sample.

The most commonly used methods of analysis were thickness, refractive index (nD), short UV, and color.

# Examination Results

Could the questioned glass particles in Items 2 and/or 3 have originated from the store's broken window as represented by Item 1?

TABLE 1

WebCode	Item 2	Item 3	WebCode	Item 2	Item 3
2C4WJX	No	Yes	JD3RXK	No	Yes
2F38EX	No	Yes	JQ6K23	No	Yes
2NGWFR	No	Yes	JTCKJ3	No	Yes
2TCML3	No	Yes	KFGQLY	No	Yes
37EGPK	No	Yes	KFYV2C	No	Yes
3LMPAK	No	Yes	KRU79X	No	Yes
3MGFDE	No	Yes	KYCJ8X	No	Yes
49GUQJ	No	Yes	KYTQEZ	No	Yes
4E3L3H	No	Yes	L8MV82	No	Yes
4PZUGE	No	Yes	MHDGHP	No	Yes
4RQTX	No	Yes	N2CNH9	No	Yes
4UWBWU	No	Yes	N3J9XV	No	Yes
6FRJL9	No	Yes	PDYDQD	No	Yes
7JMT9F	No	Yes	R7C76Q	No	Yes
84EU6J	No	Yes	R847LA	No	Yes
9UK9CP	No	Yes	RLK6AM	No	Yes
A2C3NE	No	Yes	RTPWK7	No	Yes
A8KB84	Yes	No	RXH2CP	No	Yes
ADRXZ8	No	Yes	T77GAR	No	Yes
AFJWFQ	No	Yes	TP3KDN	No	Yes
B4XC8E	No	Yes	TUV2BZ	No	Yes
B6TYL4	No	Yes	UCQUWX	No	Yes
BK8VAC	No	Yes	UJR7RU	No	Yes
BQCYV6	No	Yes	UU9VMT	No	Yes
C2BR7G	No	Yes	UV4H2H	No	Yes
C8DYKJ	No	Yes	V9P6TV	No	Yes
CQ8JH4	No	Yes	VHPH6P	No	Yes
D3YPP8	No	Yes	VU6MX7	No	Yes
DEUU2D	No	Yes	VWVP4U	No	Yes
EMHCQ7	No	Yes	WD9RYK	No	Yes
ET7VBA	No	Yes	WHRPT3	No	Yes
F93A9H	No	Yes	WVFPJ6	No	Yes
FQX2UF	No	Yes	XFJNWX	No	Yes
GLWDQD	No	Yes	Y3NZP2	No	Yes
H7J7B9	No	Yes	YJBNVQ	No	Yes
HKJZN3	No	Yes	YJFZHL	No	Yes

TABLE 1

WebCode	Item 2	Item 3	WebCode	Item 2	Item 3
YT22YW	No	Yes			
ZPFPRD	No	Yes			
ZRJC9N	No	Yes			

<b>Response Summary</b>		<b>Total Participants: 75</b>	
<i>Could the questioned glass particles in Items 2 and/or 3 have originated from the store's broken window as represented by Item 1?</i>			
		<u>Item 2</u>	<u>Item 3</u>
<b>Response</b>	Yes	1 (1.3%)	74 (98.7%)
	No	74 (98.7%)	1 (1.3%)
	Inconclusive	0 (0.0%)	0 (0.0%)

# Examination Procedures

TABLE 2

WebCode	Refractive Index					Density	Thickness	Elemental		UV			Other
	nD	nF	nC	$\Delta$ RI	Color			SEM/ EDS	XRS/ XRF	Long	Short	Other	
2C4WJX							✓	✓					
2F38EX	✓				✓		✓		✓	✓	✓		
2NGWFR	✓			✓	✓		✓						
2TCML3	✓				✓		✓		✓	✓	✓	solubility in water, probing for hardness, microscopic exam	
37EGPK	✓				✓		✓		✓	✓	✓		
3LMPAK	✓				✓		✓		✓	✓	✓	PLM	
3MGFDE	✓						✓		✓		✓		
49GUQJ	✓						✓		✓		✓		
4E3L3H	✓				✓		✓		✓	✓	✓		
4PZUGE				✓			✓	✓			✓		
4RQTX												ICP-MS	
4UWBWU	✓				✓		✓			✓	✓		
6FRJL9	✓						✓	✓			✓		
7JMT9F	✓				✓		✓		✓	✓	✓		
84EU6J	✓	✓	✓	✓	✓	✓	✓			✓	✓		
9UK9CP	✓				✓		✓			✓	✓	LA-ICP-MS	
A2C3NE	✓				✓		✓		✓	✓	✓		
A8KB84								✓				FTIR	
ADRXZ8	✓				✓		✓	✓			✓	LA-ICP-MS	
AFJWFQ	✓			✓	✓		✓				✓		
B4XC8E	✓				✓		✓				✓	LIBS, LA-ICP-MS	
B6TYL4	✓				✓		✓	✓		✓	✓		
BK8VAC	✓	✓	✓		✓		✓			✓	✓		
BQCYV6	✓			✓	✓		✓				✓	LIBS	
C2BR7G	✓				✓	✓	✓			✓	✓		
C8DYKJ	✓						✓					LA-ICP MS	
CQ8JH4								✓	✓				

TABLE 2

WebCode	Refractive Index					Density	Thickness	Elemental		UV		
	nD	nF	nC	$\Delta$ RI	Color			SEM/ EDS	XRS/ XRF	Long	Short	Other
D3YPP8						✓			✓			LIBS
DEUU2D	✓				✓		✓			✓	✓	LIBS
EMHCQ7	✓				✓		✓		✓			
ET7VBA	✓				✓		✓			✓	✓	
F93A9H	✓				✓		✓					
FQX2UF	✓				✓		✓		✓			
GLWDQD	✓						✓			✓	✓	
H7J7B9	✓			✓	✓		✓	✓				✓
HKJZN3	✓	✓	✓		✓		✓			✓	✓	
JD3RXK								✓				
JQ6K23	✓				✓		✓		✓	✓	✓	
JTCKJ3	✓				✓		✓			✓	✓	Elemental analysis - Inductively-coupled plasma optical emission spectroscopy
KFGQLY	✓	✓			✓		✓				✓	Elemental Analysis: ICP-OES
KFYV2C	✓				✓		✓		✓	✓	✓	
KRU79X	✓						✓					✓
KYCJ8X				✓	✓		✓	✓		✓	✓	Stereo Mikroskop
KYTQEZ					✓		✓			✓	✓	ICP-MS
L8MV82	✓						✓	✓		✓	✓	
MHDGHP	✓				✓	✓			✓			
N2CNH9	✓				✓		✓			✓	✓	
N3J9XV	✓				✓		✓					✓
PDYDQD				✓	✓		✓		✓	✓	✓	
R7C76Q	✓				✓		✓	✓				✓
R847LA	✓			✓			✓					
RLK6AM	✓				✓		✓	✓	✓	✓	✓	
RTPWK7	✓				✓		✓		✓			
RXH2CP	✓			✓	✓		✓			✓	✓	

TABLE 2

WebCode	Refractive Index					Density	Thickness	Elemental		UV		
	nD	nF	nC	$\Delta$ RI	Color			SEM/ EDS	XRS/ XRF	Long	Short	Other
T77GAR	✓				✓		✓		✓	✓	✓	
TP3KDN	✓			✓	✓		✓	✓				
TUV2BZ	✓			✓	✓		✓			✓		
UCQUWX											✓	LA-ICP-MS
UJR7RU	✓				✓		✓		✓	✓	✓	
UU9VMT	✓				✓		✓		✓	✓	✓	Morphology via stereomicroscopy
UV4H2H							✓		✓			
V9P6TV				✓			✓	✓		✓	✓	
VHPH6P	✓				✓		✓			✓	✓	ICP-OES
VU6MX7							✓		✓			LA-ICP-MS
VWVP4U	✓				✓		✓		✓		✓	
WD9RYK	✓						✓			✓	✓	
WHRPT3	✓				✓		✓				✓	
WVFPJ6	✓				✓		✓	✓			✓	
XFXJNW	✓				✓		✓			✓	✓	
Y3NZP2	✓				✓		✓	✓			✓	
YJBNVQ				✓	✓		✓	✓				
YJFZHL	✓				✓		✓			✓	✓	
YT22YW	✓			✓	✓		✓				✓	
ZPFPRD	✓						✓					
ZRJC9N	✓				✓		✓		✓	✓	✓	

### Response Summary

Participants	Refractive Index					Density	Thickness	Elemental		UV	
	nD	nF	nC	$\Delta$ RI	Color			SEM/ EDS	XRS/ XRF	Long	Short
75	60	4	3	15	54	4	68	18	26	37	56
Percent	80%	5%	4%	20%	72%	5%	91%	24%	35%	49%	75%



# Conclusions

TABLE 3

WebCode	Conclusions
2C4WJX	The evidence (elemental composition of glass samples as well as the thickness measurements) provides support for the proposition that glass fragments recovered from the suspect's shoe (Item 2) could have not originated from the broken window (Item 1) whereas glass fragments recovered from the suspect's jacket (Item 3) could have originated from the broken window (Item 1).
2F38EX	Based on our analysis the questioned glass fragments recovered from the suspect's shoe (Item 2) could be differentiated from the reference material from the broken window (Item 1). Item 2 must therefore originate from an unknown source. Based on our analysis the questioned glass fragments recovered from inside the hood of the suspect's jacket (Item 3) could not be differentiated from the reference material from the broken window (Item 1).
2NGWFR	The findings provide moderately strong support for the view that the two glass fragments recovered from the hood of the suspect's jacket (item 3) originated from the broken window of the electronic store (item 1), rather than from a different source. The two glass fragments recovered from the suspect's shoe (item 2) did not originate from the broken window of the electronic store (item 1), the fragments originated from a different source.
2TCML3	<p>1. Examination for Characteristics of Glass: a. Laboratory items 1 through 3 were tested using a probe and examined visually and microscopically with the aid of a polarized light microscope. In addition, they were tested for solubility in water. i. Laboratory items 1 through 3 were found to be hard, isotropic, insoluble in water, and exhibited conchoidal fractures, which are all class characteristics of glass. 2. Comparison: a. Examination of Laboratory item 3 (Q2a) and comparison to Laboratory item 1 (Ka) disclosed that they are consistent and no discriminating differences were observed with respect to color, appearance, thickness, response to UV light, elemental composition, and refractive index. b. Examination of Laboratory item 2 (Q1a / Q1b) and comparison to Laboratory item 1 (Ka / Kb) disclosed that they are different with respect to their thickness and reaction to UV light. c. The additional glass particles comprising Laboratory items 1 (Kb) and 3 (Q2b) were not instrumentally analyzed. Therefore, no additional conclusions can be made regarding these particles. d. Visual and microscopic examinations of Laboratory items 1 through 3 failed to disclose the presence of a physical match. A)INTERPRETATION OF RESULTS: 1. It is the opinion of the undersigned that Laboratory item 3 (Q2a) could have originated from the same source as Laboratory item 1 (Ka) or another source exhibiting all of the same analyzed characteristics. 2. It is the opinion of the undersigned that Laboratory item 2 (Q1a / Q1b) could not have originated from the source represented by Laboratory item 1 (Ka / Kb). 3. It is the opinion of the undersigned that Laboratory items 1 through 3 were not once joined together.</p>
37EGPK	<p>1. Comparative examinations of Exhibit 1 (known glass taken from the broken window) with Exhibit 3 (questioned glass recovered from inside the hood of the suspect's jacket) disclosed them to be consistent in physical characteristics, refractive indices, and elemental compositions. Therefore, Exhibit 3 could have originated from Exhibit 1, or another source with the same characteristics. 2. Comparative examinations of Exhibit 1 with Exhibit 2 (questioned glass recovered from the suspect's shoe) disclosed them to be inconsistent in physical characteristics. Therefore, Exhibit 2 could not have originated from Exhibit 1. 3. It should be noted a glass association is not a means of positive identification and the number of possible sources for a specific glass is unknown.</p>
3LMPAK	The following methodologies were used in the examination of this case: visual examination, physical examination, microscopy, digital calipers, UV fluorescence, XRF and GRIM3.

TABLE 3

WebCode	Conclusions
	Examination showed the glass in Item #3 is consistent in physical properties, elemental composition and refractive index with the glass in Item #1. These fragments could have shared a common origin. Item #2 and Item #1 were not consistent in physical properties and elemental composition. These items could not have shared a common origin.
3MGFDE	1. I have considered the following propositions to evaluate my findings: a. The glass fragments recovered from the suspect's shoe and/or jacket originated from the broken window. b. The glass fragments recovered from the suspect's shoe and/or jacket originated from an unrelated source and are present due to chance. 2. Given the above, I consider the findings to be more probable if the first proposition is true for the recovered glass from the jacket, that is, the glass fragments recovered from the suspect's jacket originated from the broken window rather than the second that the glass was present by chance. 3. Consequently it is my opinion that the recovered glass fragments from the suspect's shoe (Item 2) can be excluded from having originated from the broken window on differences observed in the analysis. The findings provide moderate support for the proposition that the recovered glass fragments from the suspect's jumper (Item 3) originated from the broken window (Item 1).
49GUQJ	Exhibits 2 and 3 were compared to the glass standard in Exhibit 1 to determine whether they could have come from the same broken window. The methods of comparison included all or some of the following techniques: thickness measurements using a digital caliper, determination of manufacturing method via visual, stereomicroscopic and ultraviolet lighting examination, assessment of elemental composition via X-ray Fluorescence Spectroscopy (XRF) and measurement of refractive index using the Glass Refractive Index Measurement System (GRIM3). Exhibit 2 was differentiated from Exhibit 1 by thickness, elemental composition and manufacturing method. Therefore, the glass sample from the suspect's shoe cannot have originated from the broken window represented by Exhibit 1. Exhibit 3 was consistent with Exhibit 1 in thickness, manufacturing method, elemental composition and refractive index. It cannot be differentiated from the glass standard provided. Therefore, the glass sample from the suspect's jacket could have originated from the broken window represented by Exhibit 1, or from another broken glass object that shares all these characteristics.
4E3L3H	The following methodologies were used in the examination of this case: visual examination, physical examination, microscopy, digital calipers, UV fluorescence, XRF and GRIM3. No association was found between the known glass taken from the broken window (item #1) and the questioned glass recovered from the suspect's shoe (item #2). Analysis showed the known glass taken from the broken window (item #1) and the questioned glass recovered from inside the hood of the suspect's jacket (item #3) were consistent in physical properties, refractive index, and elemental composition. These fragments could have shared a common origin.
4PZUGE	Items 1, 2 and 3 each contained 2 fragments of broken glass. Each fragment comprised full thickness and was consistent in appearance with float glass. Questioned glass from the suspect's shoe (Item 2) showed significant differences in surface fluorescence when compared to glass from the broken door (Item 1). As a result, it is my opinion that glass recovered from the suspect's shoe did not originate from the same source as glass from the broken door. Questioned glass from the suspect's jacket (Item 3) showed no significant differences in surface fluorescence, thickness, refractive index or chemical composition when compared to glass from the broken door (Item 1). It is my opinion that glass recovered from the suspect's jacket may have originated from the same source as glass from the broken door.
4RQTX	Item 2 is distinguishable from Item 1 by 24 of 44 elements using the +/- 4 standard deviation criteria and therefore could not have originated from the same source. Item 3 is not distinguishable from Item 1 by comparing 44 elements using the +/- 4 standard deviation criteria and therefore could have originated from the same source.

TABLE 3

WebCode	Conclusions
4UWBWU	The glass from questioned "item 3" was found to be consistent 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 1". The glass from questioned "item 2" was found to be inconsistent with the known glass "item 1". Therefore, the glass from the "item 2" could not have come from the same source as the glass from "item 1".
6FRJL9	[No Conclusions Reported.]
7JMT9F	Comparative examinations of Exhibit 1 (known glass standard from the broken window) with Exhibit 2 (questioned glass fragments recovered from the suspect's shoe) disclosed them to be inconsistent in their physical characteristics and elemental compositions. As a result of these findings, the questioned glass (Exhibit 2) could not have originated from the broken window (Exhibit 1). Comparative examinations of Exhibit 1 (known glass standard from the broken window) with Exhibit 3 (questioned glass fragments recovered from inside the hood of the suspect's jacket) disclosed them to be consistent in their physical characteristics, refractive indices, and elemental compositions. As a result of these findings, the questioned glass (Exhibit 3) could have originated from the broken window (Exhibit 1) or another source with the same characteristics. A glass association is not a means of positive identification and the number of possible sources for a specific glass is unknown.
84EU6J	Glass samples from Items 2 and 3 were compared to Item 1. All three are clear colorless flat glass. Items 1 and 3 are consistent with respect to their physical characteristics, including color, thickness, fluorescence, optical properties (refractive index and dispersion) and relative density. Therefore, Item 3 originated from the broken window as represented by Item 1, or from another source of broken flat glass exhibiting all of the same analyzed characteristics. Item 2 is different from Item 1 in thickness, fluorescence, optical properties (refractive index and dispersion) and relative density. Therefore, Item 2 could not have originated from the broken window as represented by Item 1.
9UK9CP	The questioned glass fragments from "Item 3" were examined and found to have no significant differences from the control glass fragments from "Item 1" in terms of colour, fluorescence, refractive index and trace elemental composition. Hence, the questioned glass fragments from "Item 3" were very likely to have originated from the same source as the control glass fragments from "Item 1", other sources of glass with similar characteristics are limited. The questioned glass fragments from "Item 2" were examined and found to be different from the control glass fragments from "Item 1" in terms of fluorescence, refractive index, and trace elemental composition. Hence, the questioned glass fragments from "Item 2" did not originate from the same source as the control glass fragments from "Item 1".
A2C3NE	Items 1, 2, and 3 were examined by stereomicroscopy, ultraviolet light fluorescence, and micrometry. Items 1 and 3 were additionally examined by X-ray fluorescence spectroscopy and refractive index determination. The glass in Item 3 is indistinguishable from the glass in Item 1 in optical, physical, and elemental properties (Type 3 Association). This means the glass recovered from inside the hood of the suspect's jacket could have come from the broken window. The glass in Item 2 is different from the glass in Item 1 (Elimination). This means the glass recovered from the suspect's shoe did not come from the broken window.
A8KB84	Combining results from FTIR and SEM/EDS techniques, we conclude that the particles of glass recovered from the suspect's shoe (Item 2) could not be excluded as having originated from the glass taken from the broken window (Item 1), as the two glass samples have a very similar chemical composition. However, the particles of glass recovered from the inside of the hood of the suspect's jacket (Item 3) could be excluded as having originated from the glass taken from the broken window (Item 1) as the two glass samples differ in chemical composition.

TABLE 3

WebCode	Conclusions
ADRXZ8	<p>Item 1 comprised two full thickness fragments of colourless float glass collected from the victim's broken window (control glass). The fragments were found to have an average thickness of 2.17mm, an average refractive index of 1.5191 and were principally composed of the oxides of Si, Na, Mg, and Ca. Item 2 comprised two full thickness fragments of colourless glass recovered from the suspect's shoe. One fragment was found to have a thickness of 2.26mm and the other fragment was found to have a thickness of 2.25mm. Both fragments had an average refractive index of 1.5170. These fragments did not correspond in thickness or refractive index to the control glass (Item 1) and could not have originated from the victim's broken window (Item 1). Item 3 comprised two full thickness fragments of colourless glass recovered from the inside hood of the suspect's jacket. Both fragments were found to have a thickness of 2.17mm, an average refractive index of 1.5192 and were principally composed of the oxides of Si, Na, Mg, and Ca. These fragments statistically corresponded in refractive index and corresponded in appearance, thickness, gross elemental composition and trace elemental concentrations to the control glass (Item 1). These results strongly support the proposition that the glass fragments recovered from the inside hood of the suspect's jacket (Item 3) originated from the victim's broken window (Item 1).</p>
AFJWFQ	<p>Item 1: The control glass from the broken window was examined and its physical characteristics were noted. Item 2: The two fragments of glass in Item 2 were examined when the refractive index of each was found to be different from that of the control glass, such that, the two fragments of glass in Item 2 did not originate from the broken window represented by Item 1. Item 3: The two fragments of glass in Item 3 were examined when each was found to be similar in colour and refractive index to the control glass. One of these fragments was examined further and shown to be similar in thermal history to the control glass in Item 1 such that it could have originated from the broken window represented by Item 1.</p>
B4XC8E	<p>The glass (Item 001-3) recovered from inside the hood of the suspect's jacket was indistinguishable in physical appearance, refractive index and elemental composition from the glass (Item 001-1) taken from the broken window. Therefore, the glass recovered from the hood of the suspect's jacket could have originated from the broken window or from another source of glass produced by the same glass manufacturer exhibiting the same physical and chemical properties. The glass (Item 001-2) recovered from the suspect's shoe had a different refractive index than the glass (Item 001-1) recovered from the broken window; therefore, it did not come from this window.</p>
B6TYL4	<p>It was found that item 3 could have originated from item 1, item 2 could not have originated from item 1.</p>
BK8VAC	<p>The glass in Item 2 displayed different fluorescence and thickness than the known glass in Item 1. Therefore, the Item 2 glass did not come from the same source as Item 1 (Exclusion). A glass fragment from Item 3 corresponded in general appearance, thickness, fluorescence, and refractive index (GRIM - 656nm, 589nm and 488 nm) to the known glass in Item 1. Therefore, Items 1 and 3 could have come from a common source; however, more sensitive testing methods could allow for greater discrimination, which limits this association (Type IV Association). Other glass may have been manufactured to the same specifications that would be indistinguishable from the submitted evidence.</p>
BQCYY6	<p>The two fragments of glass from the suspect's shoes (item 2) had a different refractive index and thickness to the glass from the broken window (item 1). Therefore, in my opinion, these two fragments of glass have not come from the broken window. The two fragments of glass from the suspect's jacket (item 3) were both flat, float, non-toughened glass and had the same refractive index and thickness as the glass from the broken window (item 1). These two fragments were</p>

TABLE 3

WebCode	Conclusions
	<p>also compared to the glass from the broken window by their elemental compositions, which were determined using LIBS (laser induced breakdown spectroscopy). The two fragments of glass from the suspect's jacket could not be excluded as coming from the broken window using this technique. Therefore, in my opinion, the two fragments of glass from the jacket could have come from the broken window. However, other sources of glass are possible. Surveys show that approximately 0.3% of vehicle glass would have the same refractive index and thickness as these fragments of glass. No samples were present in either the building glass survey or the container glass survey that were the same type of glass with the same refractive index and thickness as the two fragments of glass from the jacket. In my opinion, this correspondence very strongly supports the suggestion that the glass from the jacket has come from the broken window.</p>
C2BR7G	<p>Items 1, 2 and 3 were examined visually, microscopically, by thickness, and refractive index. Items 1 and 3 were found to be consistent with respect to thickness and refractive index. Based on these findings, it is the opinion of the analyst that items 1 and 3 could have come from the same source, or any other source exhibiting the same analyzed characteristics. Items 1 and 2 were found to be inconsistent with respect to thickness and refractive index, and therefore could not have come from the same source.</p>
C8DYKJ	<p>The fragments taken from the broken window (known fragments, ITEM 1) and fragments recovered from inside the hood of the suspect's jacket (questioned, ITEM 3), show the same results in all the analyzes performed (chemical composition and physical properties). Both of them are significantly different from ITEM 2 (questioned glass recovered from the suspect's shoe).</p>
CQ8JH4	<p>The sample 2 must have a different origin than the sample 1. The sample 3 may have the same origin as sample 1.</p>
D3YPP8	<p>The chemical composition of all three samples was determined with LIBS and <math>\mu</math>XRF. The comparison of the chemical composition of the samples showd a good congruence between Item 1 and 3. Additionally, the density of the samples was determined. Item 1 and 3 have an identical density value. The density value of Item 2 differs clearly from the other value. Conclusion: Item 3 originates from the same object as Item 1.</p>
DEUU2D	<p>The questioned glass in Item 3 is consistent with the known glass in Item 1 on the basis of color, thickness, luminescence, elemental composition, and refractive index. Therefore, Item 3 could have originated from the known glass in Item 1. The questioned glass in Item 2 is not consistent with the known glass in Item 1 on the basis of thickness, elemental composition, and refractive index.</p>
EMHCQ7	<p>The glass in Item 1.1 and the glass in Item 1.3 were found to be alike in all measured characteristics. Therefore, the glass in Item 1.1 and the glass in Item 1.3 may have the same origin. The glass in Item 1.2 was found to be dissimilar to the glass in Items 1.1 and 1.3.</p>
ET7VBA	<p>The glass from the suspect's shoe (Item 2) could not have originated from the same source as the glass standard from the broken window (Item 1). (Elimination); The glass from the suspect's jacket (Item 3) either originated from the same source as the glass standard from the broken window (Item 1) or from another source of glass with the same optical and physical properties (Level IV Association). This level of association was reached due to a limited analysis. Elemental analysis was not performed.</p>
F93A9H	<p>On analysis, I found:- i. The refractive index of the questioned glass from inside the hood of the suspect's jacket (item 3) to be similar with the refractive index of the known glass taken from the broken window (item 1). ii. The refractive index of the questioned glass from inside the hood of the suspect's shoe (item 2) to be different with the refractive index of the known glass taken from the broken window(item 1). Therefore, I am of the opinion that:- i. The questioned glass from</p>

TABLE 3

WebCode	Conclusions
	inside the hood of the suspect's jacket (item 3) and the known glass taken from the broken window (item 1) could have come from the same source. ii. The questioned glass from inside the hood of the suspect's shoe (item 2) and the known glass taken from the broken window (item 1) did not come from the same source.
FQX2UF	[No Conclusions Reported.]
GLWDQD	Item 2 is not consistent with Item 1. Item 3 is consistent with Item 1.
H7J7B9	The results of the examination give support for the hypothesis that the glass particles in Item 3 originate from the broken window represented by Item 1 (Level +2); The results of the examination gives extremely strong support for the hypothesis that the glass particles in Item 2 do not originate from the broken window represented by Item 1 (Level -4)
HKJZN3	Physical and microscopic examination and analysis of CTS 19-548-a item #1, known glass, in conjunction with CTS 19-548-b item #2, questioned glass, revealed them to be inconsistent with respect to optical properties. Therefore, CTS 19-548-b item #2 could not have come from the source represented by CTS 19-548-a item #1. Physical and microscopic examination and analysis of CTS 19-548-a item #1, known glass, in conjunction with CTS 19-548-c item #3, questioned glass, revealed them to be consistent with respect to optical and physical properties. Therefore, CTS 19-548-c item #3, could have come from the source represented by CTS 19-548-a item #1
JD3RXK	The polished cross-sections were first examined in the SEM for polymeric coatings, none were found on either of the flat surfaces. Five EDS spectra were collected from different regions of the polished cross-sections of glass fragments. The average compositions of Items 2 and 3 were plotted against the average composition of Item 1. If they are equivalent, the scatter plot will lie on the line $y=x$ within a reasonable degree of uncertainty. For Item 3 this was true, indicating that it is compositionally identical to item 1. Item 2 had two statistically relevant elements, Al and Ca, that did not match the composition of Item 1. Therefore, while all three glasses appear to be of the same soda-lime glass type, only Item 3 is an exact match for Item 1. Since it is a question of origination rather than type, only Item 3 could have originated from Item 1.
JQ6K23	The glass from Item 3 (glass from jacket) was found to be similar in color, thickness, fluorescence, elemental composition, and refractive index in comparison to the glass from Item 1 (known glass from window) and could have originated from the same source of glass as Item 1 or from any other source of glass with similar color, thickness, fluorescence, elemental composition, and refractive index. The glass from Item 2 (glass from shoe) was found to be different in thickness, fluorescence, and elemental composition in comparison to the glass from Item 1 (standard) and did not come from the same source of glass as Item 1. Item 1 and Item 3 were examined visually and using stereomicroscopy, polarized light microscopy (PLM), a digital caliper, X-Ray fluorescence spectroscopy (XRF), and Glass Refractive Index Measurement System (GRIM3). Item 2 was examined visually and using stereomicroscopy, polarized light microscopy (PLM), a digital caliper, and X-Ray fluorescence spectroscopy (XRF). Samples analyzed in this case have been returned to and retained with the original items.
JTCKJ3	Glass recovered from the jacket (Item 3) is indistinguishable from glass from the window (Item 1). Consequently, the glass from the jacket (Item 3) either originated from the window (Item 1) or from another source of broken glass indistinguishable in all of the measured or observed physical properties, refractive index, and elemental composition (an inclusion). Glass recovered from under the shoe (Item 2) is different in thickness from the glass from the window (Item 1). Consequently, the glass recovered from under the shoe (Item 2) did not originate from the window as represented by Item 1 (an exclusion).

TABLE 3

WebCode	Conclusions
KFGQLY	Glass recovered from the suspect's jacket (Item 3) is indistinguishable from glass from the broken window (Item 1). Consequently, the glass from the suspect's jacket (Item 3) either originated from the broken window (Item 1) or from another source of broken glass indistinguishable in all of the measured or observed physical properties, refractive index, and elemental composition. This is an "Inclusion". Glass recovered from suspect's shoes (Item 2) is different in thickness than the glass from the broken window (Item 1). Consequently, the glass recovered from the suspect's shoes (Item 2) did not originate from the broken window as represented by Item 1. This is an "Exclusion".
KFYV2C	The two particles of questioned glass recovered from the suspect's shoe (item 2) are different from the two fragments of known glass taken from the broken window (item 1) : they don't come from the same origin. The two particles of questioned glass recovered from inside the hood of the suspect's jacket (item 3) can come from the known glass taken from the broken window (item 1) or from another glass material with the same characteristics.
KRU79X	Based on visual examination and RI (using the t-test) the recovered glass from Item 2 could be differentiated from the control glass Item 1. Therefore, the recovered glass from Item 2 could not have come from the same source as Item 1. Based on visual examination and RI (using the t-test) the recovered glass from Item 3 could not be differentiated from the control glass Item 1. Therefore, the recovered glass from Item 3 could have come from the same source as Item 1. In my opinion, the evidence weakly supports the proposition that the suspect was in the vicinity of the window at the electronic store at the time that it was breaking, however another source with similar physical characteristics cannot be excluded.
KYCJ8X	It was determined that item1 and item3 were similar in terms of physical chemical properties. It was determined that item1 and item2 were different in terms of physical and chemical properties.
KYTQEZ	Physical and instrumental comparison of the two glass fragments from item 3 to the two glass fragments from item 1 revealed them to be the same with respect to physical properties and elemental composition. Therefore, the fragments from item 3 came from the source represented by the fragments from item 1 or a source with identical physical properties and elemental composition. Physical and instrumental comparison of the two glass fragments from item 2 to the two glass fragments from item 1 revealed them to be inconsistent with respect to physical properties and elemental composition. Therefore, the fragments from item 2 could not have come from the source represented by the fragments from item 1.
L8MV82	Item 1 RESULTS: Clear glass was analyzed for comparison to Items 2 and 3. Item 2 RESULTS: Two pieces of clear glass were found. The unknown glass from the suspect's shoe and the standard glass (Item 1) from the broken window are not the same in physical and optical characteristics. The unknown glass from the suspect's shoe could not have originated from the standard. Item 3 RESULTS: Two pieces of clear glass were found. The unknown glass from inside the hood of the suspect's jacket either originated from the standard glass (Item 1) from the broken window or another source of broken glass possessing the same distinct physical, optical, and chemical characteristics.
MHDGHP	Item 3 could have originated from item 1 (broken window).
N2CNH9	The glass recovered from the suspect's shoe does not match several properties of the known glass from the broken window, and therefore cannot originate therefrom. The glass recovered from the inside of the hood of the suspect's jacket however cannot be differentiated from the glass of the broken window by the methods used, and therefore can have originated therefrom. As no data are available on the frequency of occurrence of this type of glass, no statement can be made about the strength of this evidence.

TABLE 3

WebCode	Conclusions
N3J9XV	The two particles recovered from inside the hood of the suspect's jacket (item 3) are indistinguishable to the glass from the broken window (item 1) in glass refractive index, color, and thickness. This result suggests the opinion these glass particles may originate from this broken window. The two particles recovered from the suspect's shoes (item 2) are different in refractive index and thickness to the glass from the broken window (item 1). Therefore these particles could not have originated from this broken window.
PDYDQD	Item #2 - Glass from shoe - Different from the known glass (Item #1) with respect to thickness and UV fluorescence - Exclusion. Item #3 - Glass from hood of jacket - Indistinguishable from the known glass (Item #1) with respect to color, texture, thickness, UV fluorescence, refractive index and elemental composition - Could have originated from the same source (1). (1) This association is not exclusive; other manufactured items with the same characteristics may exist. Remarks: The evidence is being returned to your department. Digital images are being retained at [Laboratory]. Analytical Detail: These findings were determined using microscopical examination techniques (stereomicroscope, PLM) and instrumental analyses (digital micrometer, rIQ, micro-XRF).
R7C76Q	In relation to thickness, fluorescence properties, refractive index and elemental composition the two glass fragments recovered from the hood of the jacket (item 3) were found to be indistinguishable from the window glass (item 1). Therefore the glass from these items may share a common origin. The two fragments of glass recovered from the shoe (item 2) were each found to have a different thickness to the window glass (item 1) and therefore could not have originated from the window.
R847LA	The evidence gives very strong support to the hypothesis that glass from Item 1 and Item 2 do not originate from the same source (-3). The evidence gives strong support to the hypothesis that glass from Item 1 and Item 3 originates from the same source(+2).
RLK6AM	The particles of questioned glass recovered from inside the hood of the suspect's jacket (Item 3) could have been originated from the store's broken window (Item 1) because of their similarities of their physical properties and chemical composition. The particles of questioned glass recovered from the suspect's shoe (Item 2) could not have been originated from the store's broken window (Item 1) because of their differences of their physical properties and chemical composition.
RTPWK7	It was determined utilizing visual examination and measurement, Glass Refractive Index Measurement System (GRIM3), and X-Ray Fluorescence that the glass samples from item 1 and item 3 exhibit consistent color, thickness, refractive index and elemental composition. Therefore, based on those characteristics the known sample from item 1 cannot be eliminated as being the source of the questioned glass from item 3. It was determined utilizing visual examination and measurement, Glass Refractive Index Measurement System (GRIM3), and X-Ray Fluorescence that the glass samples from item 1 and item 2 exhibit dissimilar thickness and elemental composition. Therefore, based on those characteristics the known sample from item 1 can be eliminated as being the source of the questioned glass from item 2.
RXH2CP	The two pieces of broken glass from the suspect's shoe (item 2) are eliminated as having come from the broken window from the electronics store (item 1). The two pieces of broken glass from the suspect's jacket (item 3) cannot be eliminated as having come from the broken window from the electronics store (item 1). Therefore, these pieces of glass either came from the broken window or from another source or sources of glass indistinguishable from the broken window in the properties listed in the results.
T77GAR	The glass recovered from inside the hood of the suspect's jacket Item3, was indistinguishable in



TABLE 3

WebCode	Conclusions
	<p>physical and chemical properties (thickness, colour, UV Fluorescence, refractive index and elemental composition) to the glass taken from the broken window Item1, therefore, The glass recovered from inside the hood of the suspect's jacket Item3, could have originated from the glass taken from the broken window Item1 or from another source exhibiting the same physical and chemical properties. The glass recovered from the suspect's shoe Item2, could not have originated from the glass taken from the broken window Item1.</p>
TP3KDN	<p>The two particles of glass recovered from the suspect's shoe (item two) were found to be different in thickness and refractive index from the glass from the broken window (item one). In my opinion the glass particles recovered from the suspect's shoe could not therefore have originated from the broken window at the electronic store, as represented by item one. The two particles of glass recovered from inside the hood of the suspect's jacket (item three) were found to correspond with the glass from the broken window (item one) in the results of the comparisons undertaken (colour, thickness, refractive index, chemical composition and the results of heat treatment). The particles of glass recovered from inside the hood of the suspect's jacket could, in my opinion, have originated from the broken window at the electronic store, as represented by item one.</p>
TUV2BZ	<p>Particles of questioned glass recovered from the inside the hood of the suspect's jacket (Item 3) could have a common origin with glass fragments of known glass taken from the broken window (Item 1). Particles of questioned glass from the suspect's shoe (Item 2) are different from glass fragments of known glass (Item 1).</p>
UCQUWX	<p>[No Conclusions Reported.]</p>
UJR7RU	<p>Items 1, 2, and 3 were examined by stereomicroscopy, micrometry, and ultra-violet fluorescence. Items 1 and 3 were additionally examined by X-ray fluorescence spectroscopy and refractive index determination. The glass in Item 3 was indistinguishable from the glass in Item 1 in optical, physical, and elemental properties (Type 3 Association). This means that the glass recovered from inside of the hood of the suspect's jacket could have come from the broken window. The glass in Item 2 was different from the glass in Item 1 (Elimination). This means that the glass recovered from the suspect's shoe did not come from the broken window.</p>
UU9VMT	<p>The sample in Item 1 consists of two colorless glass fragments that exhibit characteristics consistent with non-tempered float sheet (window) glass. These fragments have their full thickness. They were used as standards for comparison to the glass in Items 2 and 3. Item 2 consists of two colorless glass fragments that have their full thickness and exhibit characteristics consistent with non-tempered sheet (window) glass. Macroscopic and microscopic examinations and comparisons of Items 1 and 2 revealed significant differences between them with respect to their fluorescence under ultraviolet lamps. Item 1 is consistent with float glass while Item 2 is not. Therefore, the glass from the subject's shoe could not have originated from the broken store window as represented by Item 1. Item 3 consists of two colorless glass fragments that have their full thickness and exhibit characteristics consistent with non-tempered float sheet (window) glass. Macroscopic, microscopic and instrumental examinations and comparisons of Items 1 and 3 revealed that they are like one another with respect to their color, thickness, refractive index values and chemical characteristics. It is therefore concluded that the glass fragments recovered from the hood of the subject's jacket originated either from the broken store window or from another source of broken non-tempered float sheet glass having these same characteristics.</p>
UV4H2H	<p>On the basis of the results obtained, due to the differences in the elemental composition and thickness between Item 1 and Item 2, it was considered that Item 1 was an unlikely source of Item 2. Conversely, due to the similarities in elemental composition and thickness between Item 1 and Item 3, it was considered that Item 1 was the source of Item 3.</p>

TABLE 3

WebCode	Conclusions
V9P6TV	It is possible that item 1 and item 3 came from the same origin; it is impossible that item 1 and item 2 came from the same origin.
VHPH6P	Glass recovered from the debris from the hood of the suspect's jacket (Item 3) is indistinguishable in the observed and measured physical properties, refractive index, and elemental composition from the glass recovered from the broken window (Item 1). Therefore, the glass recovered from the debris from the hood of the suspect's jacket (Item 3) either originated from the broken window as represented by Item 1, or from another source of broken glass indistinguishable in all the observed and measured physical properties, refractive index, and elemental composition (an inclusion). Glass recovered from the debris from the suspect's shoes (Item 2) is different than the glass recovered from the broken window (Item 1). Accordingly, the broken window as represented by Item 1 is eliminated as a possible source of the glass recovered from the debris from the suspect's shoes (Item 2) (an exclusion).
VU6MX7	The chemical compositions of Item 3 glasses are similar with Item 1 glasses. However, the content of Al, K, Ti, Zr and Ba elements in Item 2 glasses are different from Item 1's constituents.
VWVP4U	Questioned glass fragments recovered from the suspect's jacket (Item 3) and known glass from a broken window (Item 1) were compared using physical characteristics, UV fluorescence, refractive index measurements, and elemental analysis by X-Ray Fluorescence (XRF). The tested questioned glass fragments were similar in color, thickness, type (float), refractive index, and elemental composition to the known glass. The broken window from which the known glass was recovered is a possible source of the tested questioned glass fragments recovered from the suspect's jacket (Level 3 - Association). Because other items have been manufactured that would also be indistinguishable from the submitted evidence, an individual source cannot be determined. Questioned glass fragments recovered from the suspect's shoe (Item 2) and known glass from a broken window (Item 1) were compared using physical characteristics, UV fluorescence, and elemental analysis by X-Ray Fluorescence (XRF). The tested questioned glass fragments differed in UV fluorescence and elemental composition from the known glass. The questioned glass from the suspect's shoe did not originate from the broken window from which the known glass was collected. (Elimination)
WD9RYK	Conclusions: I formed the opinion based on the techniques used, that the glass fragments recovered from the suspect's jacket hood, (item 3) had the same appearance and refractive index as the control glass collected from the broken window (item 1) and could have come from it. I also formed the opinion based on the techniques used, that the glass fragments recovered from the suspect's shoe, (item 2) had a different thickness and refractive index to the control glass collected from the broken window (item 1) and could not have come from it.
WHRPT3	The glass fragments from inside the hood of the suspect's jacket (Item 3) and from the broken window (Item 1) are both float glasses and have a thickness of around 2,16 - 2,17 mm. The glass from the suspect's shoe (Item 2) has a thickness of around 2,25 and 2,27 mm and shows no fluorescence on the surface in the UV light. Item 2 and Item 1 also differ in their refractive indices. The glass fragments from Item 3 and Item 1 cannot be differentiated by their refractive indices, their thickness and color. Therefore the questioned glass particles from inside the hood of the suspect's jacket (Item 3) may have originated from the broken window (Item 1). As glass is a mass product, a matching refractive index is not an individual match, but a different refractive index proves the origin from different sources.
WVFPJ6	Examination and comparison of the representative glass from Items 1 and 2 revealed glass dissimilar in optical properties. They could not have come from the same source. Examination and comparison of the representative glass from Items 1 and 3 revealed glass similar in all measured physical, optical, and elemental properties. They could have come from the same

TABLE 3

WebCode	Conclusions
	source or any other source with the same properties.
XFXJNW	Items 1, 2, and 3 were examined visually and using a digital caliper and ultraviolet light. In addition, Items 1 and 3 were further examined using the Glass Refractive Index Measurement system (GRIM3). It should be noted that this examination did not include elemental analysis. The Item 2 glass fragments could not be associated with the Item 1 glass due to differences in float properties and thickness. The Item 3 glass fragments were consistent with the Item 1 glass in type, color, temper, float properties, thickness, and refractive index. It was concluded that these Item 3 fragments could have originated from the broken glass source represented by Item 1 or another source of broken glass with the same properties. Date(s) of testing: 07/09/2019 - 07/24/2019.
Y3NZP2	In my opinion my findings provide moderate support for the proposition that the pieces of glass found in the hood of the jacket (Item 3) originated from the broken window (Item 1). In my opinion my findings show that the pieces of glass recovered from inside the shoe (Item 2), could not have originated from the broken window (Item 1). The strength of the evidence or likelihood ratio in relation to either proposition considered is assessed on a scale of: no support for either proposition, limited, moderate, moderately strong, strong, and very strong. Each point on the scale represents a numerical range, which has a logarithmic basis such that each increment provides ten times greater support than the previous one.
YJBNVQ	The questioned glass particles in Item 3 agreed in colour, thickness, elemental composition and refractive index with the known glass fragments in Item 1 whereas the questioned glass particles in Item 2 did not. Therefore, the questioned glass particles recovered from inside the hood of the suspect's jacket in Item 3 could have originated from the same source as Item 1, i.e., the broken window. Conversely, the questioned glass particles recovered from the suspect's shoe in Item 2 could not have originated from the said broken window.
YJFZHL	Two particles of glass recovered from the suspect's shoe (Item 2) are dissimilar in thickness, fluorescence, and refractive index to the fragments of glass taken from the broken window (Item 1). It is our opinion that these particles of glass did not originate to the fragments of glass taken from the broken window. Two particles of glass recovered from inside the hood of the suspect's jacket (Item 3) are similar in visual color, thickness, fluorescence, and refractive index to the fragments of glass taken from the broken window (Item 1). Please note trace elemental comparison between the glass recovered from inside the hood of the suspect's jacket and the glass taken from the broken window cannot be performed by our laboratory at this time. It is our opinion that these particles of glass could share a common origin to the fragments of glass taken from the broken window. Item 1 was used as a comparison standard.
YT22YW	I have considered the proposition that the two particles of glass recovered from inside the hood of the suspect's jacket item 3 could have originated from glass from the broken window of the electronic store as represented by the submitted control item 1; the results of this examination provide support for this proposition. The two particles of glass recovered from the suspect's shoe item 2 did not originate from the broken window of the electronic store as represented by item 1.
ZPFPRD	The evidence was examined on 7/8/19 via automated glass refractive index (GRIM2) and thickness measurement. The questioned glass from Item 3 was consistent in thickness and refractive index with the known glass from Item #1 and could have originated from this source (Level IV association). The questioned glass from Item 2 was dissimilar in thickness with the known glass from Item #1 and did not originate from this source (Elimination). The association is of lower significance (Level IV) because typically elemental analysis via laser ablation -inductively coupled plasma mass spectrometry (ICPMS) would be performed on the samples. This instrument is in the process of being moved and will not be validated in time for the due date of this test.

TABLE 3

WebCode	Conclusions
	<p>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 physical match; items physically fit back to one another, indicating 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). 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>
ZRJC9N	<p><b>CONCLUSIONS:</b> Two glass fragments identified as recovered from the jacket (Item 3) either originated from the broken window (Item 1) or another source of broken glass possessing the same distinct physical, optical, and chemical characteristics. Two glass fragments identified as recovered from the shoe (Item 2) did not originate from the broken window (Item 1). <b>RESULTS:</b> Glass identified as recovered from the shoe and jacket (Items 2 and 3) was examined for the purpose of determining whether or not it is like the known glass standard from the window (Item 1). The known glass standard from the window (Item 1) is non-tempered colorless sheet float glass. Examination and comparison of the two questioned glass fragments identified as recovered from the jacket (Item 3) with the known glass standard from the window (Item 1) reveals they are alike with respect to physical, optical, and chemical characteristics. It is therefore concluded that these two questioned glass fragments either originated from the window (Item 1) or another source of broken glass possessing the same distinct physical, optical, and chemical characteristics. Examination and comparison of the two questioned glass fragments identified as recovered from the shoe (Item 2) with the known glass standard from the window (Item 1) reveals they are dissimilar with respect to fluorescence. It is therefore concluded that these two questioned glass fragments did not originate from the window (Item 1). <b>METHODS OF ANALYSIS:</b> Examinations were performed visually, by stereo microscopy, polarized light microscopy, ultraviolet fluorescence, micrometry, refractive index determination, and x-ray fluorescence spectroscopy.</p>

# Additional Comments

TABLE 4

WebCode	Additional Comments
2C4WJX	The answer is based on results of likelihood ration calculations (elemental composition of glass).
2NGWFR	Scale: I have chosen the above phrase [Table 3 - Conclusions] from the following scale: weak support, moderate support, moderately strong support, strong support, very strong support, extremely strong support.
49GUQJ	We use a statistical method for elemental glass comparison that relies on more fragments to represent the standard object. As always, receiving only two fragments is problematic and in real casework would trigger a call to the agency to request more fragments.
6FRJL9	Conclusion: In my opinion the findings provide moderately strong support for the proposition that item 3 originated from the same source as item 1. Item 2 could not have originated from the same source as item 1.
84EU6J	Note(s): Methods of Analysis: Glass was analyzed using a combination of stereomicroscopy, high power and polarized light microscopy, ultraviolet light examination, relative density comparison, and Emmons Double Variation, which is a standard glass refractive index procedure. Elemental analysis, which is not available in this laboratory, could provide additional discrimination.
9UK9CP	Refractive index (3SD): Item 1: 1.5189 - 1.5191; Item 2: 1.5167 - 1.5173; Item 3: 1.5188 - 1.5192. Comparison of trace elemental compositions: The match criterion for LA-ICP-MS analysis was set at 4SD range (minimum 3% RSD) around the control sample. The elements compared were: Li7, Na23, Mg24, Al27, K39, Ca42, Ti49, Mn55, Fe57, Rb85, Sr88, Zr90, Ba137, La139, Ce140, Nd146, Hf178, Pb208. Comparing Item 2 and Item 3, the concentrations of the following elements were different: Li7, Al27, K39, Ca42, Ti49, Mn55, Fe57, Rb85, Sr88, Zr90, Ba137, La139, Ce140, Nd146, Hf178, Pb208."
A2C3NE	A Trace Interpretation Scale would be attached.
A8KB84	FTIR analysis was used as it can give the overall chemical profile of a material (inorganic or organic). All conclusions were based on chemical analysis, no physical measurements were carried out. In the EDS analysis, slight variations in the quantitative proportions of the different elements were noted between Items 1 and 2. Having no knowledge of the fabrication of glass, it was not known whether these variations could be considered as natural heterogeneities of the glass or warranted two different glass compositions.
AFJWFQ	A technical introduction and background information would be included at the start of the report. The fragments of glass in Item 2 were noted to be different in thickness from the fragments of glass in Item 1.
C8DYKJ	Statistical treatment: On the hand T-Test for the thickness and refraction index. on the other hand, 4SD (previous minimum 3% RSD filtered) for LA-ICP MS results.
CQ8JH4	The surfaces of the samples of item 2 containe no Sn while we found Sn on one side of every sample of item 1 and item 3. I wonder how the glass of sample 2 has been manufactured.
D3YPP8	density Item 1: 2.4964 g/cm <sup>3</sup> ; density Item 2: 2.4915 g/cm <sup>3</sup> ; density Item 3: 2.4964 g/cm <sup>3</sup> ; Please tell us how we can send the results of the LIBS and $\mu$ XRF analysis. The format of your data sheet give not the possibility to put in values in a table.
DEUU2D	It should be noted that glass does not contain enough individual chemical and microscopic characteristics to be positively identified as originating from a particular source to the exclusion of all other sources.

TABLE 4

WebCode	Additional Comments
ET7VBA	This laboratory has a uXRF capable of performing elemental analysis of glass. This examiner is not yet competent to use the uXRF. Therefore, no elemental analysis was performed on this evidence.
GLWDQD	It is necessary to do elemental analysis for Item 1 and 3. This lab cannot perform this analysis at the moment.
RXH2CP	Of the 2319 samples of broken glass from casework and survey samples from the [Location], examined at the [Laboratory] for which refractive index, thermal history, float state, and thickness data are available, 8 (~0.4%) are annealed, float glass indistinguishable from item 1 in refractive index.
TP3KDN	Further evaluation of the findings against two competing propositions relating to the case circumstances and any account given by the suspect could be possible given more detailed information.
V9P6TV	average thickness: item 1: 2.17mm item 2: 2.24mm item 3: 2.17mm. Short wave UV response: Item 1: strong item 2: weak item 3: strong. RI range: only for item 1 and 3: Item 1: 1.51879-1.51892, item 3: 1.51879-1.51899. SEM-EDS: items 1 and 3 contains Si, O, Ca, Na, Mg, Sn and traces of Al, K, Fe
VHPH6P	Results of Examinations (Conclusions) for the report are accompanied by Methods, Interpretation and Limitations sections as well as remarks regarding disposition of the evidence, discovery procedures and contact information.
Y3NZP2	When considering the frequency of occurrence in relation to the control glass sample (Item 1), I have considered three categories: common, uncommon and rare. Generally, glass types which are categorised as common have been assessed as representing about 3-5% of those routinely seen in the laboratory. Glass which is uncommon represents approximately 1-3% and rare represents less than 1%. 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 the control glass sample, Item 1, to be an uncommon type. UV light source used to examine the surfaces of glass, was used to examine the samples from items 1, 2 and 3. Item 1 was found to originate from a float source which was the same for item 3. Item 2 was from a non-float source. All the glass pieces from items 1, 2 and 3 had a full thickness. A micrometre (calibrated instrument) was used to measure the thickness for all three samples. All the samples had a similar thickness. Items 1 and 3 were closer to each other in thickness than Item 2. Glass may be retained inside a hood for an extended period of time, depending on activity of the wearer and, therefore, I cannot say how or when they were acquired.

-End of Report-  
(Appendix may follow)

## Test No. 19-548: Glass Analysis

DATA MUST BE SUBMITTED BY **Aug. 5, 2019, 11:59 p.m.** TO BE INCLUDED IN THE REPORT

Participant Code: U1234A

WebCode: RMHEEQ

The Accreditation Release section can be accessed by using the "Continue to Final Submission" button above. This information can be entered at any time prior to submitting to CTS.

### Scenario:

Police are investigating a burglary of a local electronic store. The police determined the point of entry was through a broken window. During the investigation, police apprehended a suspect at a nearby store who matched the description given by a witness. During questioning, they requested his clothing where they found particles of glass in his shoe and inside the hood of his jacket. Investigators are requesting that you examine and compare these glass particles recovered from the suspect's shoe and jacket with the fragments recovered from the broken window at the crime scene.

### *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 broken window.

Item 2: Two particles of questioned glass recovered from the suspect's shoe.

Item 3: Two particles of questioned glass recovered from inside the hood of the suspect's jacket.

**1.) Could the questioned glass particles in Items 2 and/or 3 have originated from the store's broken window as represented by Item 1?**

	Yes	No	Inconclusive
<b>Item 2:</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>Item 3:</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**2.) Indicate the procedure used to examine the submitted items:**

<input type="checkbox"/> nD <input type="checkbox"/> nF	<b><u>Refractive Index:</u></b> <input type="checkbox"/> nC <input type="checkbox"/> $\Delta$ RI	<b><u>UV Fluorescence:</u></b> <input type="checkbox"/> Long <input type="checkbox"/> Short	<input type="checkbox"/> Color <input type="checkbox"/> Density	<input type="checkbox"/> Thickness
<b><u>Elemental Analysis:</u></b> <input type="checkbox"/> SEM/EDS <input type="checkbox"/> XRS/XRF				
Other: <input type="text"/>				

*Please note: Any additional formatting applied in the free form space below will not transfer to the Summary Report and may cause your information to be illegible. This includes additional spacing and returns that present your responses in lists and tabular formats.*

**3.) What would be the wording of the Conclusions in your report?**

**4.) Additional Comments**



## RELEASE OF DATA TO ACCREDITATION BODIES

The Accreditation Release is accessed by pressing the "Continue to Final Submission" button online and can be completed at any time prior to submission to CTS.

CTS submits external proficiency test data directly to ASCLD/LAB, ANAB, and/or A2LA. 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, ANAB, and/or A2LA. (Accreditation Release section below must be completed.)
- This participant's data is **not** intended for submission to ASCLD/LAB, ANAB, and/or A2LA.

Have the laboratory's designated individual complete the following steps **only if your laboratory is accredited in this testing/calibration discipline** by one or more of the following Accreditation Bodies.

**Step 1: Provide the applicable Accreditation Certificate Number(s) for your laboratory.**

ANAB Certificate No.   
(Include ASCLD/LAB Certificate here)

A2LA Certificate No.

**Step 2: Complete the Laboratory Identifying Information in its entirety.**

Authorized Contact Person and Title

Laboratory Name

Location (City/State)