



Evaluation of Glazing Performance Testing

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Background & Objectives

- June 2012 NPRM for FMVSS No. 205 NHTSA proposed changes to harmonize the current FMVSS No. 205 with GTR No.6. [1]
 - In April 2019, NHTSA withdrew the NPRM citing its belief that current glazing materials are performing acceptably and that it could not conclude at the time whether harmonizing would increase or decrease safety. [2]
- NHTSA noted that it did not have sufficient data to evaluate the safety of harmonization and that it would be conducting a glazing research study to better inform future decisions.
- Research was initiated to examine FMVSS No. 205 “Glazing Materials” which uses impact test methods from ANSI/SAE Z26.1-1996.

[1] 77 FR 37478 (Docket No. NHTSA-2012-0083)

[2] 84 FR 13222 (Docket No. NHTSA-2019-0024)

Background & Objectives

- Objectives of the research are:
 1. Evaluate various testing situations from ANSI Z26.1 including situations for comparison with ECE R43
 - Compare results from ball test at 10ft (3.1m) and 6.6ft (2m)
 - Compare the standard shot bag to a shot bag with stiffer sidewalls
 - Examine an altered fracture test for tempered glazing with one impact point vs two (ANSI vs ECE R43)
 2. Evaluate differences in ANSI 12" x 12" flat pieces and matching production parts
 3. Learn about potential changes to tempered glass strength due to ceramic painted area (CPA)

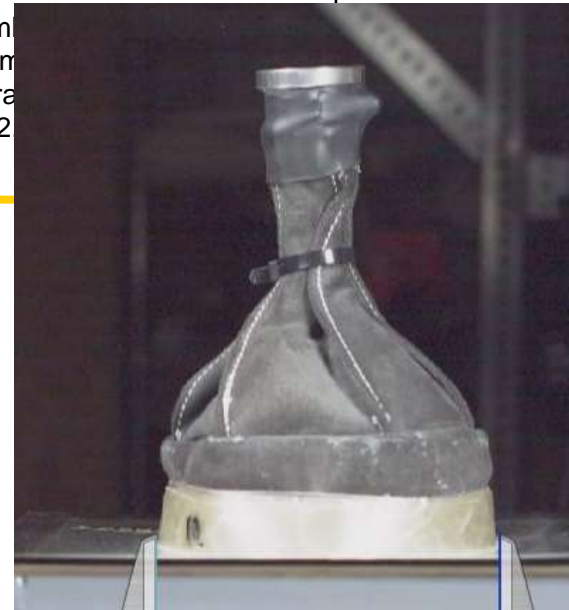
- Recent status presentations:
 - 2021 SAE Government-Industry Meeting
 - 2023 SAE Government-Industry Meeting

Standards Comparison

ANSI Z26.1-1996			ECE R43			Impact Object	Glass Type	Difference (ANSI vs ECE)
Section	Drop Height	Criteria	Section	Drop Height	Criteria			
5.6. Impact, Test 6 (Ball Drop, 3.05m [10ft])	10 ft (3.05 m)	Not more than two (of 12) specimens shall crack or break	Annex 5 Uniformly toughened glass panes, Section 3 – Mechanical strength test, 227 g ball test [2m]	6.6 ft (2 m)	At least five (of 6) test pieces do not break	224-230g (0.5lb±0.1oz) smooth, steel sphere	Tempered 12" x 12" flat specimens	Height difference: ANSI is 3.05m (10ft) and ECE is 2m (6.6ft)
5.8. Impact, Test 8 (Shot Bag)	8 ft (2.44 m)	No more than one (of 5) specimen shall crack or break	N/A	N/A	N/A	4.99 kg (11lb) shot bag	Tempered 12" x 12" flat specimens	No shot bag test in ECE R43
5.7. Fracture, Test 7	N/A	No individual fragment free of cracks, obtained within 3 minutes, shall weigh more than 4.25g (0.15 oz)	Annex 5 Uniformly toughened glass panes, Section 2 – Fragmentation test	N/A	Number of fragments in any 5x5cm square is not less than 40. Fragments shall not exceed 3cm ² , and not be longer than 100 mm in length.	Centerpunch	Tempered Production	ANSI is weight of largest piece, location is mid-point of longest edge ECE is based on count in 5x5cm square, location is geometric center

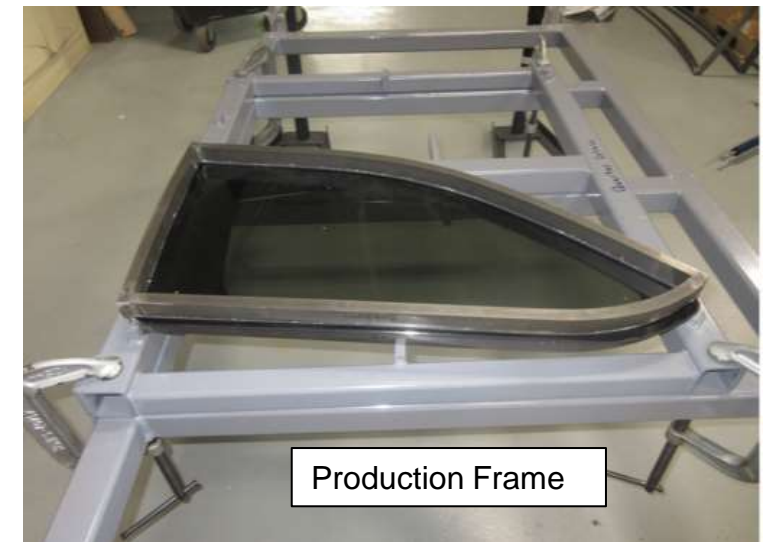
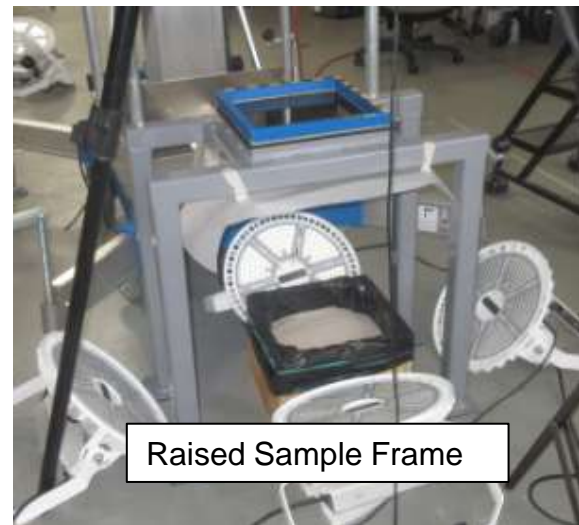
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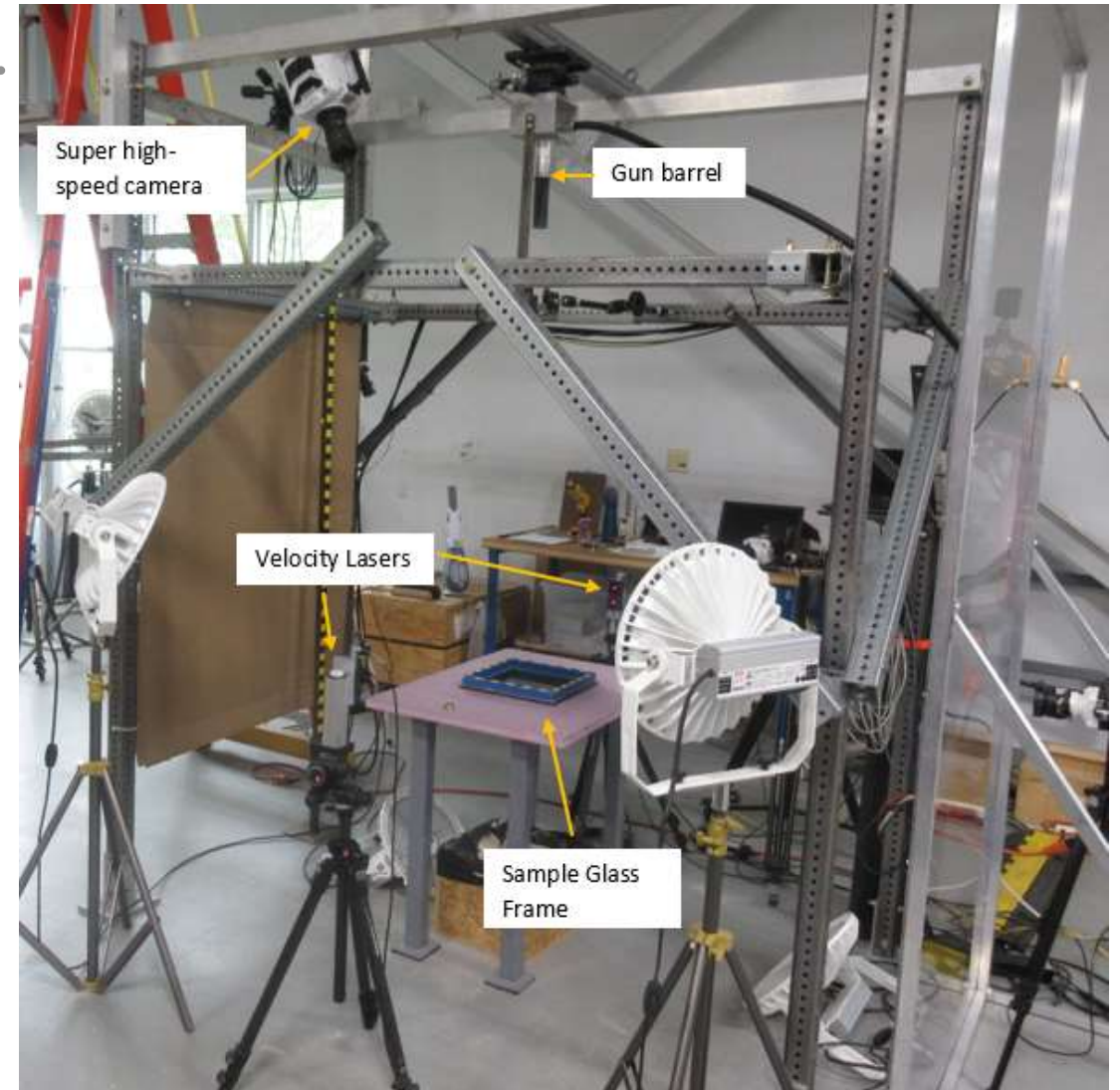
Test Equipment Overview

- Drop Tower Fixture
 - Electromagnet drop mechanism
 - Laser for targeting
 - Adjustable to different heights
 - 1ft to 14ft for ball
 - 1ft to 13ft for shot bag
- Glass support frames
 - Raised sample frame
 - Production frames fabricated for each glass type
 - Base frame can be adjusted to get perpendicular impacts on production glass



Test Equipment Overview

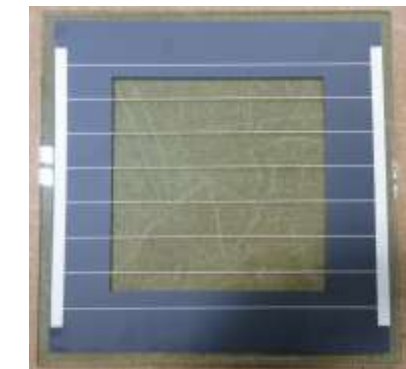
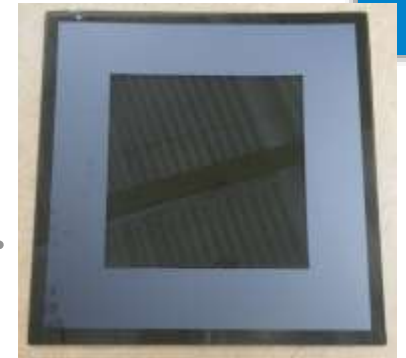
- Pneumatic Gun Fixture
 - Used for heights greater than available with tower
 - Velocity lasers - IES 2206 Velocity Measuring Laser Light Trap
- Cameras
 - Overhead view
 - Super high speed (up to 200k fps) – Phantom V2512
 - Side view
 - Phantom MIRO R-321S (1000 fps)



Glass Description

TYPE	SIZE	PAINT	THICKNESS	DESCRIPTION
Rear Quarter (RQ)	Sample (305 mm x 305 mm)	No Paint	3.5 mm	Tempered
	Production	No Paint	3.5 mm	Tempered
	Sample (305 mm x 305 mm)	Paint (50 mm Black Band)	3.5 mm	Tempered
	Production	Paint	3.5 mm	Tempered
Sunroof (SR)	Sample (305 mm x 305 mm)	No Paint	4.0 mm	Tempered
	Production	No Paint	4.0 mm	Tempered
	Sample (305 mm x 305 mm)	Paint (50 mm Black Band)	4.0 mm	Tempered
	Production	Paint	4.0 mm	Tempered
Backlight (BL)	Sample (305 mm x 305 mm)	No Paint	3.5 mm	Tempered
	Production	No Paint	3.5 mm	Tempered
	Sample (305 mm x 305 mm)	Paint (50 mm Black Band)	3.5 mm	Tempered
	Sample (305 mm x 305 mm)	Paint (50 mm Black Band) and Silver Paint Lines	3.5 mm	Tempered
	Production	Paint and Silver Paint Lines	3.5 mm	Tempered

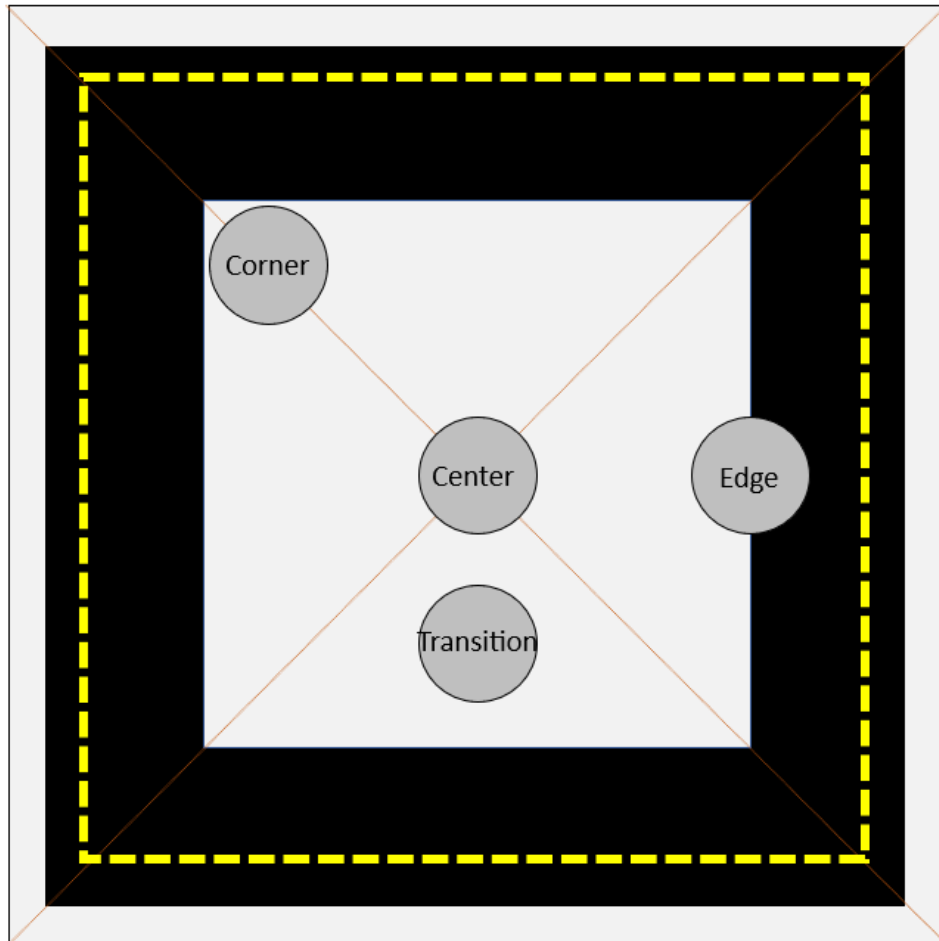
- Three types of tempered glass selected
- ANSI 12"x 12"(305 x 305 mm) samples and their corresponding production parts were obtained, both with and without CPA
 - Production BL has silver lines, for comparison purposes samples with just paint and with paint and silver lines were tested



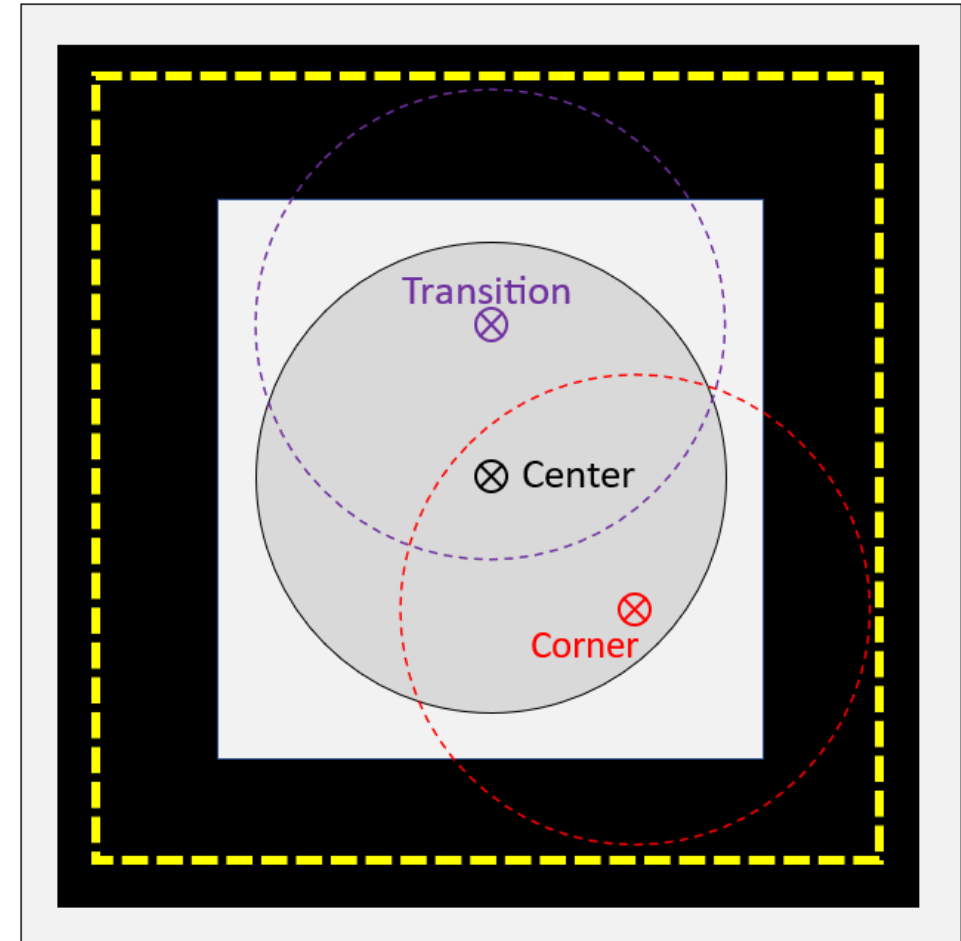
Sample glass with 50mm painted band (top), unpainted sample (middle), and painted with silver lines (bottom)

Impact Locations – Sample

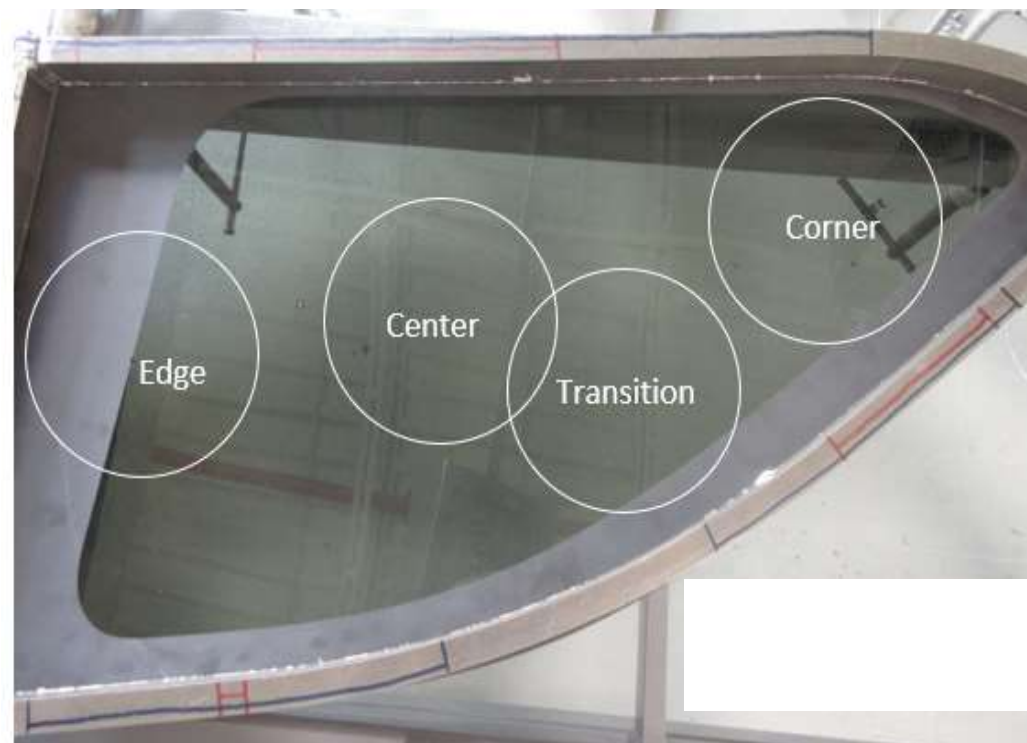
Ball
Exterior Surface



Shot Bag
Interior Surface



Impact Locations – Production



*Exemplar locations – minor differences depending on glass type impacted

Test Matrix

Glazing	Test Type			Height	# of Locations	Qty of Tests
Tempered (RQ, SR, BL)	Ball	Sample	Painted & unpainted	10 ft	4	24
			Unpainted	6.6 ft	4	24
			+	10 ft +	4	36
		Production	Painted & unpainted	10 ft	4	24
			Unpainted	6.6 ft	4	24
			+	10 ft +	4	36
	Shot Bag (ANSI)	Sample	Painted & unpainted	8 ft	3	12
			Unpainted	8 ft +	3	24
		Production	Painted & unpainted	8 ft +	6	24
			Unpainted	8 ft +	6	24
	Shot Bag (Modified)	Sample	Painted & unpainted	8 ft	3	12
			Unpainted	8 ft +	3	24
Production		Painted & unpainted	8 ft +	6	24	
		Unpainted	8 ft +	6	24	
Fracture	Production	Painted & unpainted	ANSI	mid pt of edge	12	
		Unpainted	ECE	center	12	

Standard height tests

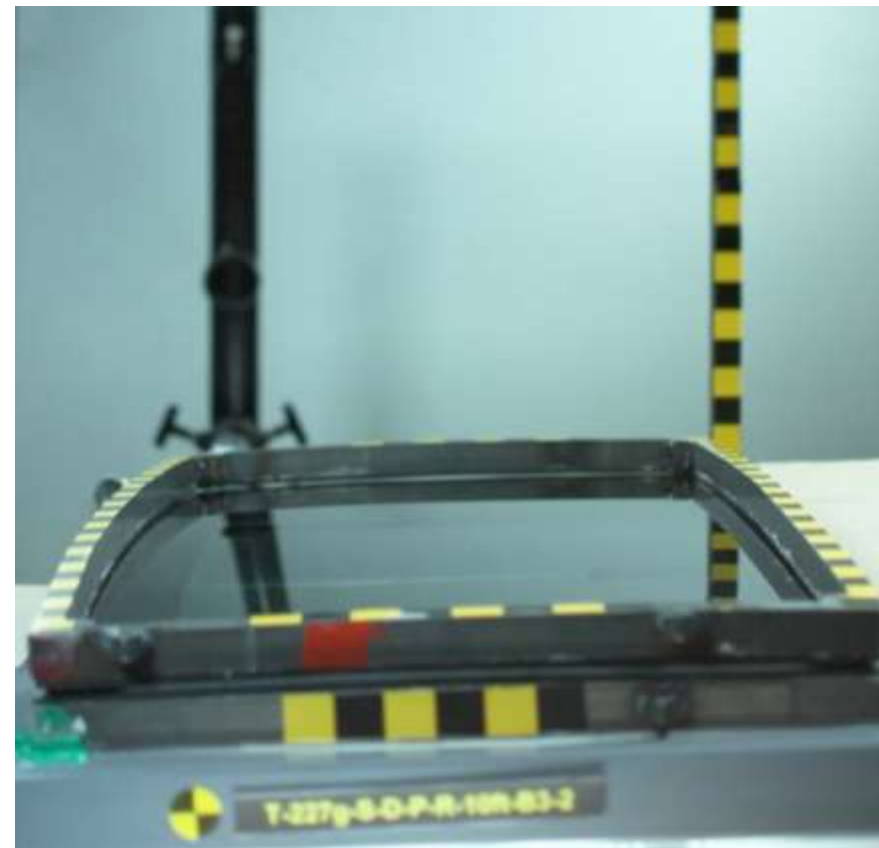
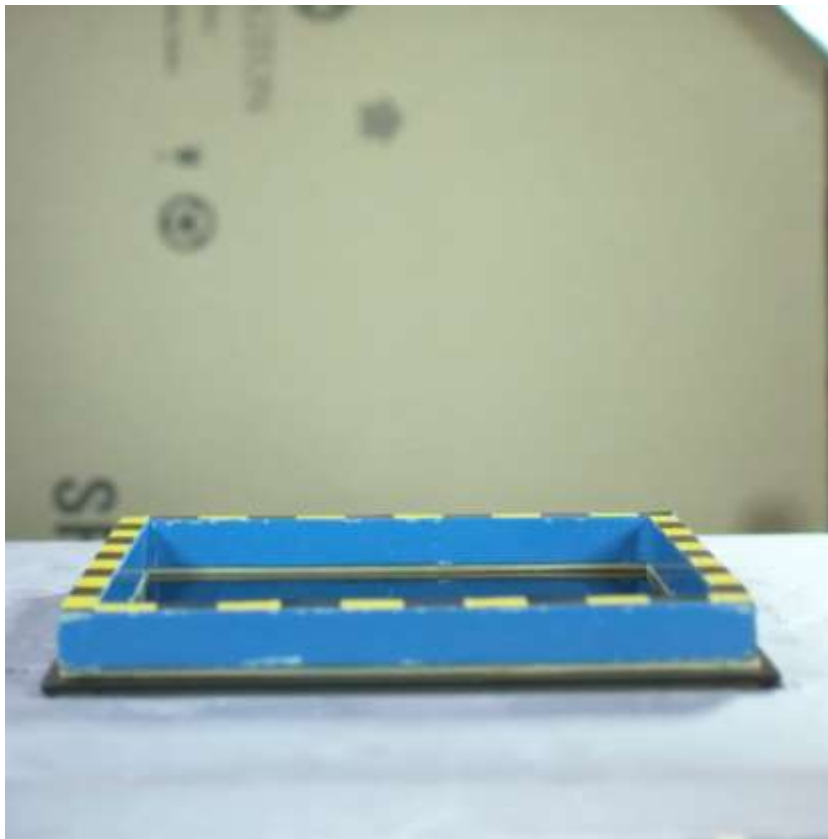
- 3 repeats at each location

Break height tests

- Indicated by “+” in matrix
- Height was increased until break was found
- Test repeated on new piece to confirm break

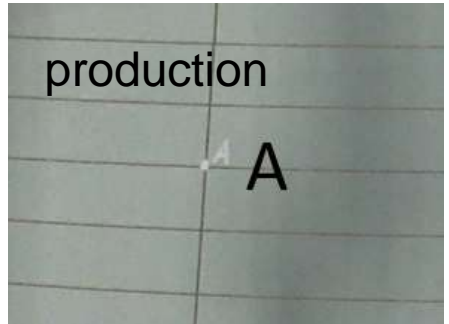
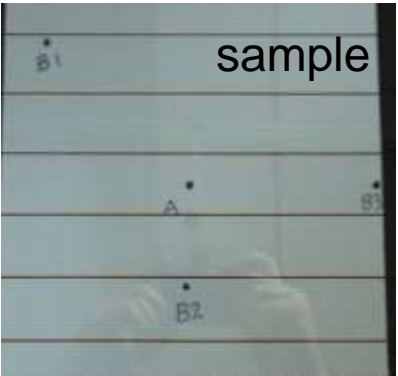
Ball Drop, 3.05m (10ft)

ANSI Z26.1-1996			ECE R43			Impact Object	Glass Type	Difference (ANSI vs ECE)
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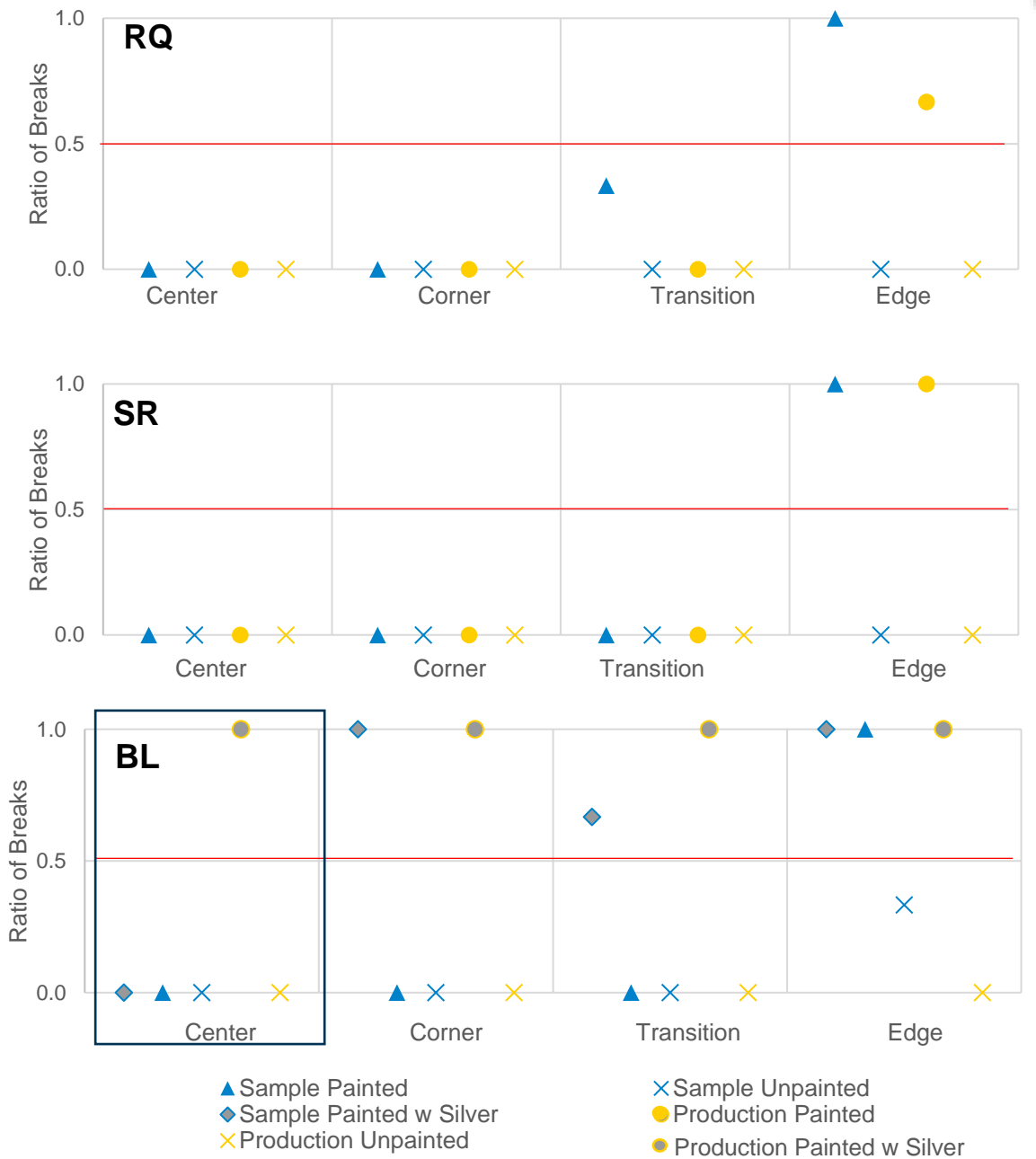


Ball Standard Tests (10ft)

- Paint weakens glass when impacted at paint edge
 - Other locations had similar results between painted and unpainted
 - Silver lines weaken glass (BL results)
- Sample and production had similar results in standard tests (86% match)
 - Backlight center location was only location where difference occurred – difference in whether impact was coinciding with silver line

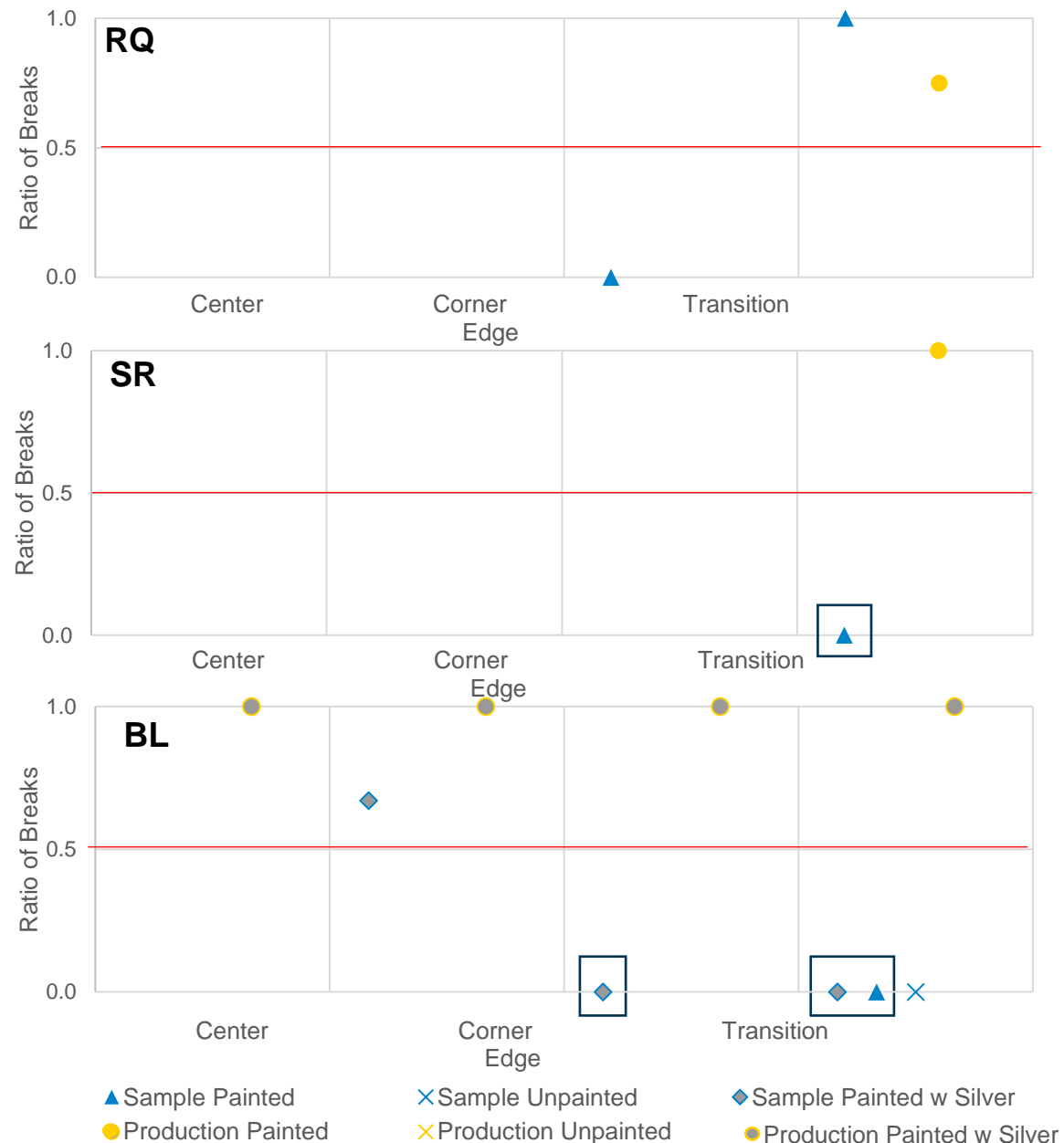


TEMPERED GLASS



Ball Standard Tests (6.6ft)

- 6.6ft tests only completed at locations where 10ft had breaks
 - Assumed that if met criteria at 10ft would meet at 6.6ft
 - 3 repeats at each location
- Compare results from ball test at 10ft (3.1m) and 6.6ft (2m):
 - At the current standard location (center) changing to a 6.6ft drop height would not change results
 - However, if impact locations were added, the 10ft drop would capture breaks that the 6.6ft did not
 - 71% (10/14 test conditions) matched result between the heights
 - Non-matching identified in figures

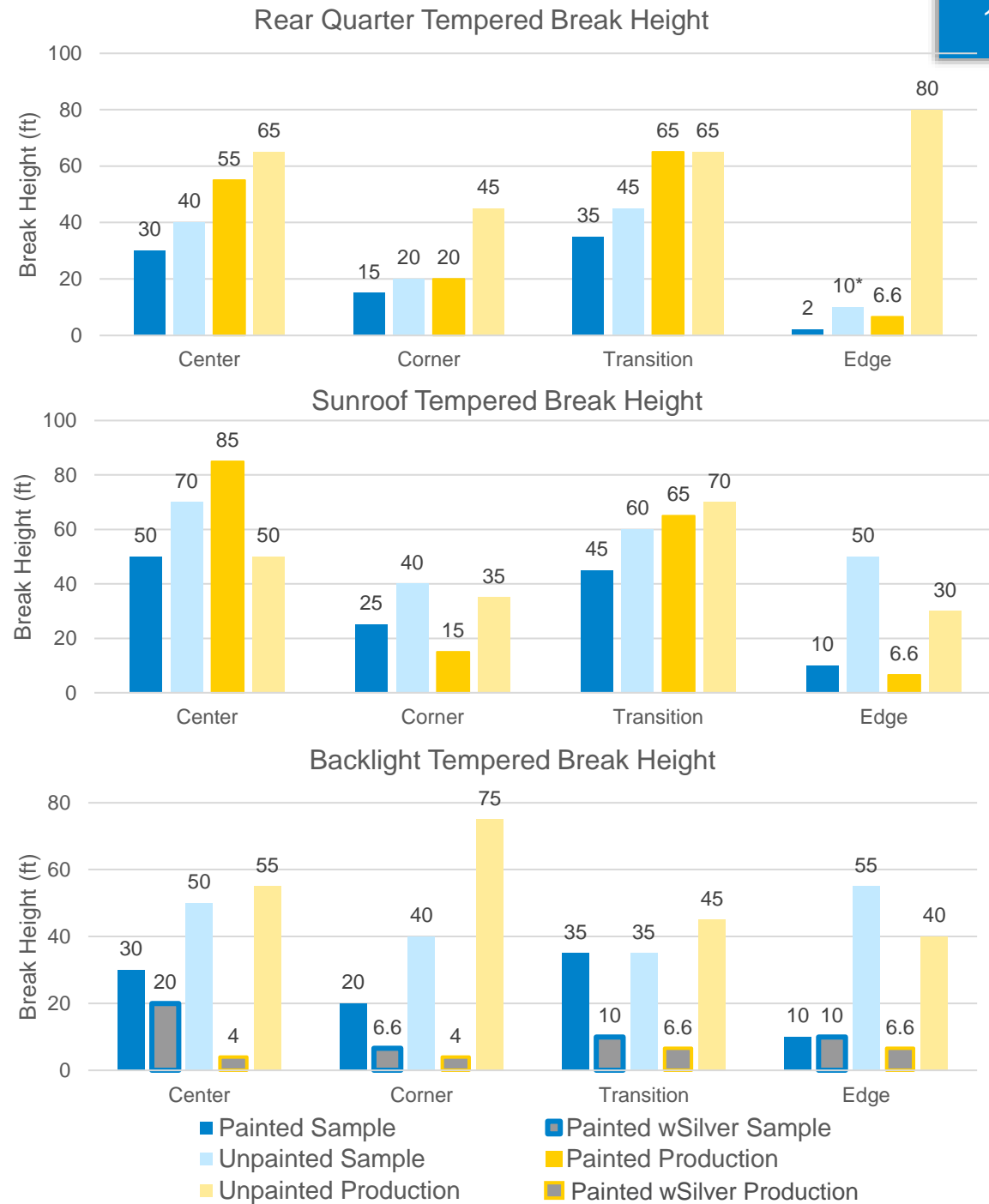


Ball Break Height

- Painted was weaker (lower break height) in every location except production SR center
 - Paint weakens glass. Silver lines also weaken
- Sample similar or slightly weaker than production
 - Exception is BL with silver lines and SR center



TEMPERED GLASS



■ Painted Sample ■ Painted wSilver Sample
■ Unpainted Sample ■ Painted Production
■ Unpainted Production ■ Painted wSilver Production

Shot Bag

ANSI Z26.1-1996			ECE R43			Impact Object	Glass Type	Difference (ANSI vs ECE)
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5.8. Impact, Test 8 (Shot Bag)	8 ft (2.44 m)	No more than one (of 5) specimen shall crack or break	N/A	N/A	N/A	4.99 kg (11lb) shot bag	Tempered 12" x 12" flat specimens	No shot bag test in ECE R43



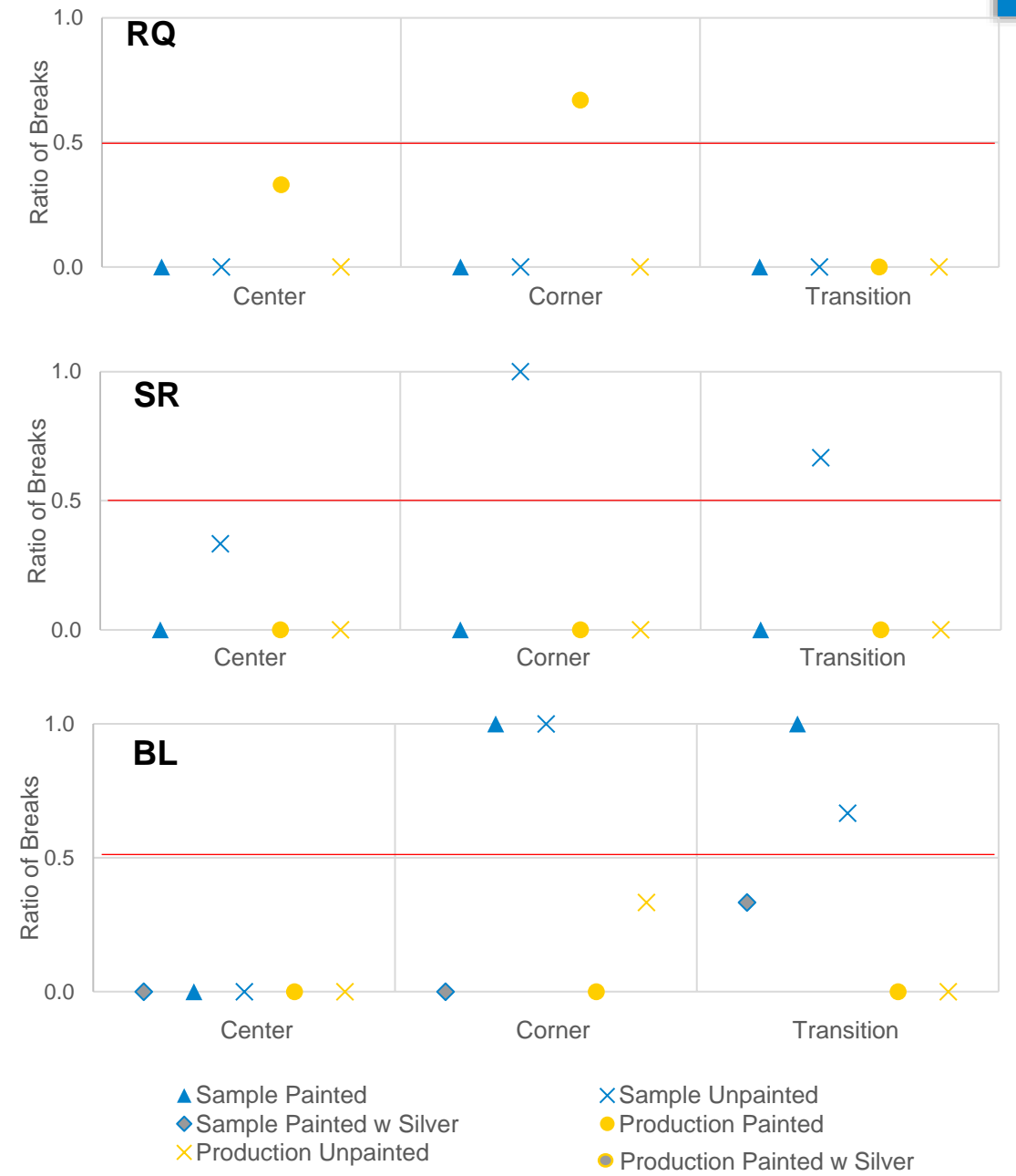
ANSI Bag



Modified (stiffened) Bag

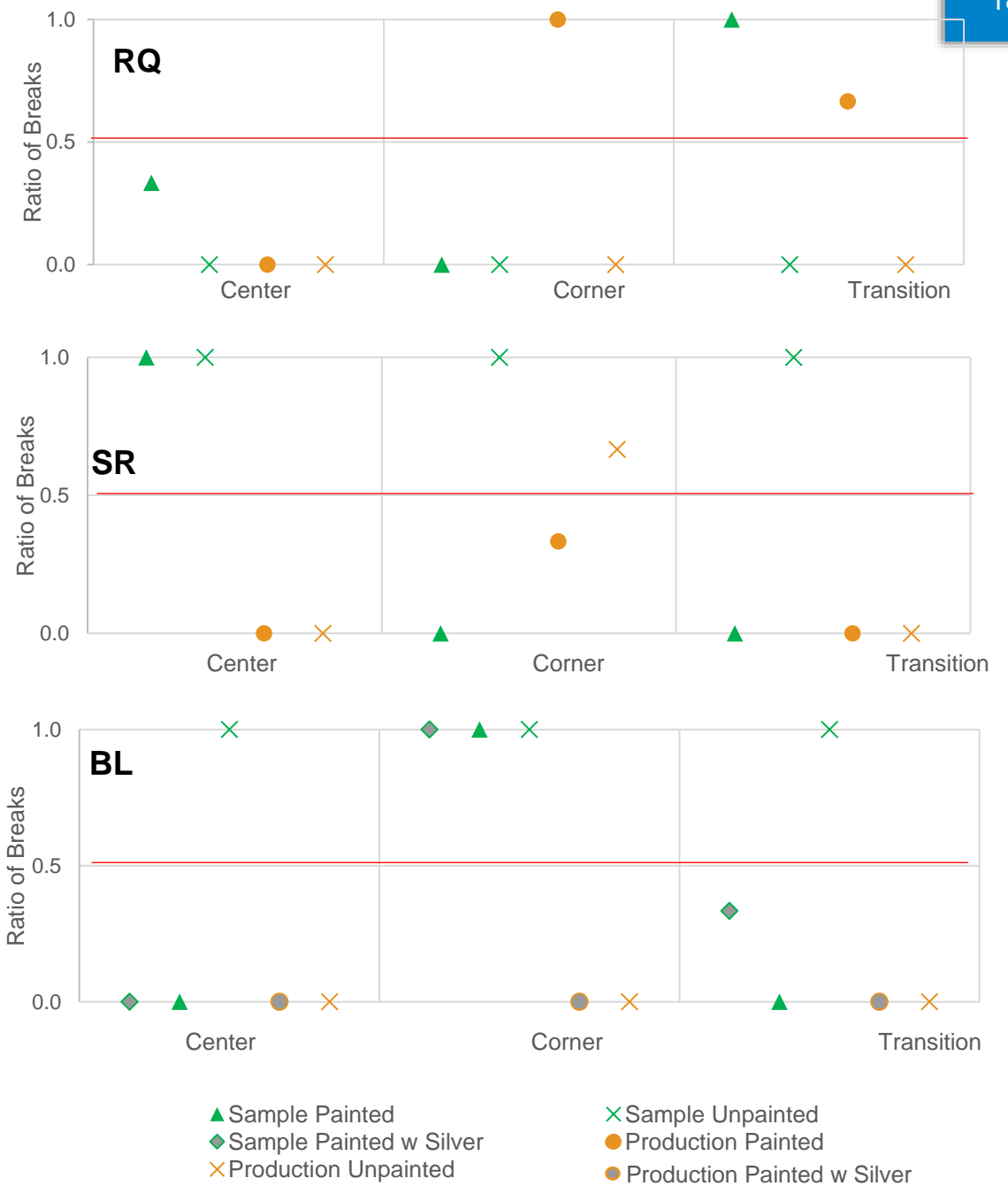
Shot Bag Standard Tests (8ft)

- Only ANSI bag shown in plots
- On SR and BL, more breaks occurred on unpainted than painted.
- 67% match between sample and production results
 - Sample broke more often than production



Stiffened Shot Bag Standard Tests (8ft)

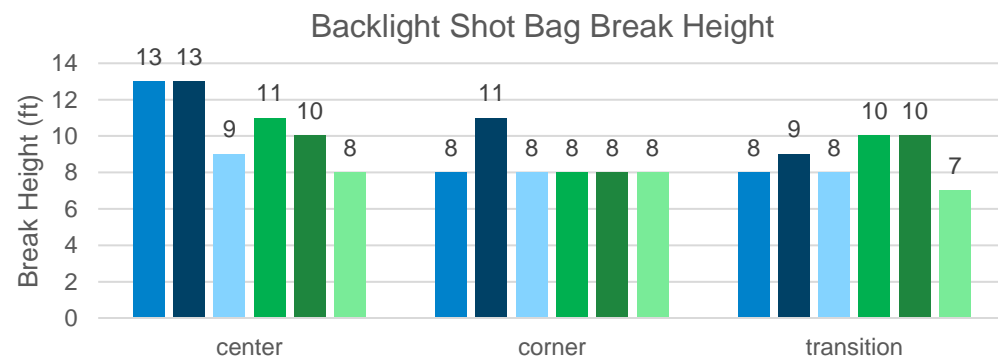
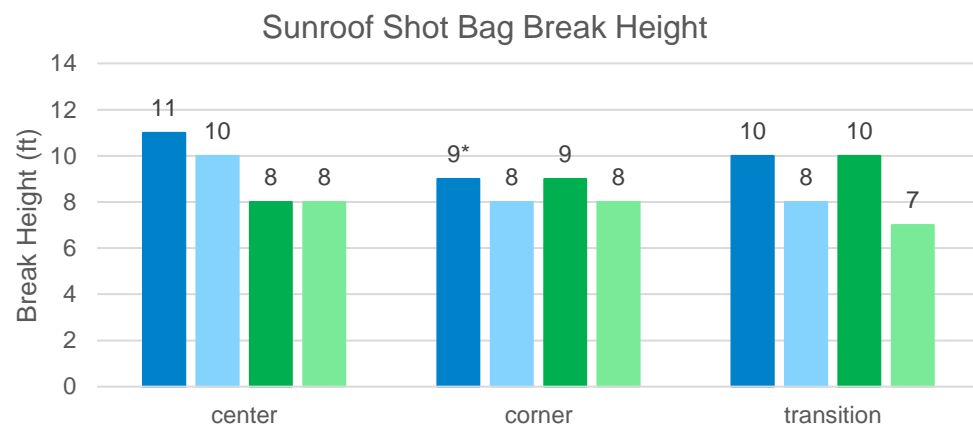
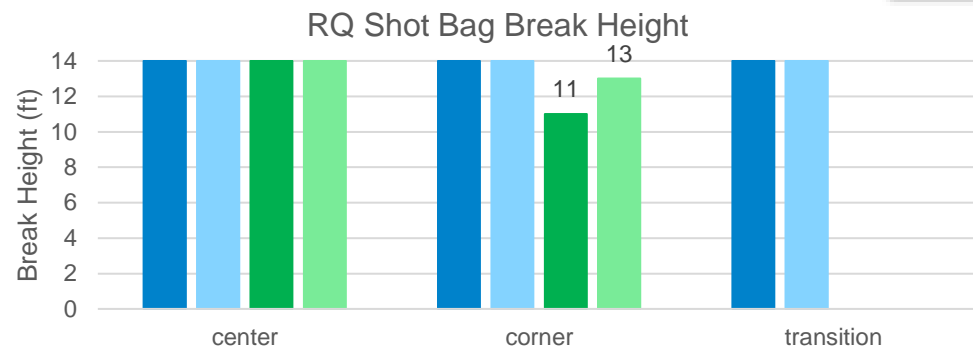
- Shot bag sidewalls were stiffened to evaluate effect on performance
- In standard tests, most locations that broke with ANSI bag also broke with stiffened bag (77% match). However, more breaks occurred with stiffened bag.
- Similar trends as ANSI Shot Bag
 - Unpainted SR and BL broke more than painted
 - Sample broke more than production (57% match)



*All sample glass

Shot Bag Break Height

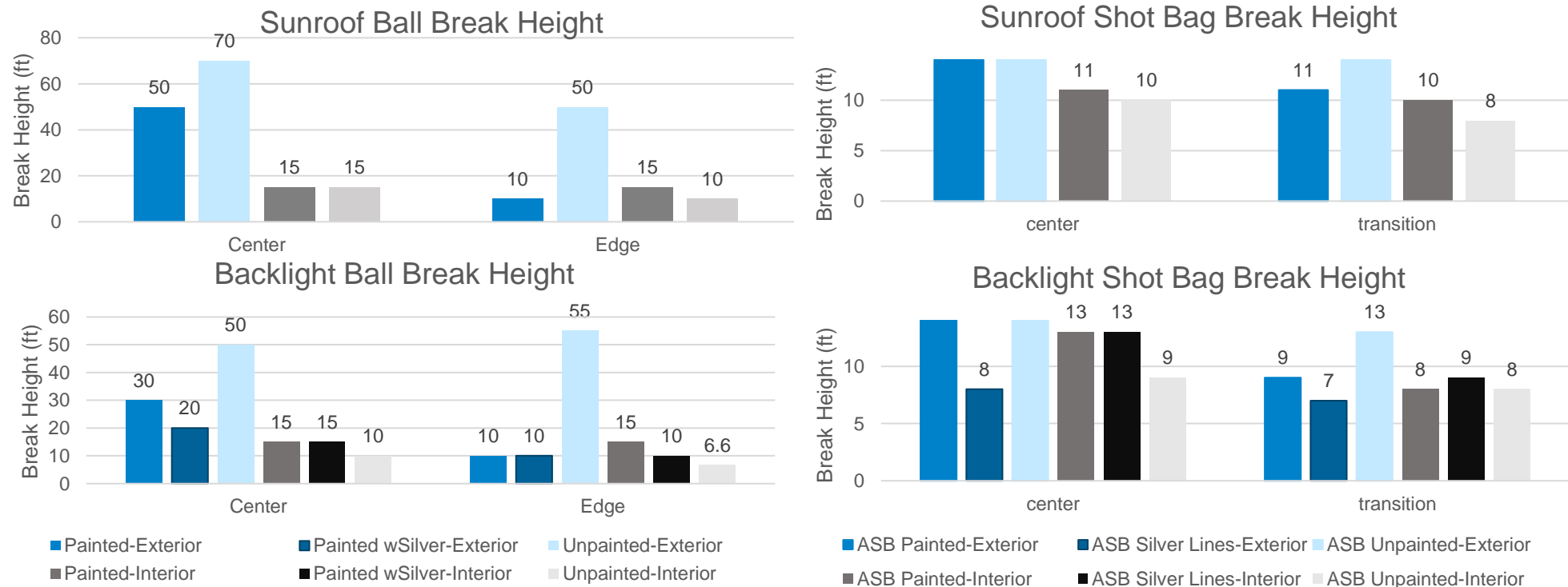
- For RQ, the break height exceeded the available height of the tower
- Shot bag tests showed painted glass was stronger or equivalent to unpainted glass
 - Different than trends with 227g ball
- Stiffened bag caused breaks at similar or lower heights than ANSI bag
 - Stiffened bag concentrates force more causing glass to seem weaker than when impacted with ANSI bag



ASB Painted ASB Silver Lines ASB Unpainted
 MSB Painted MSB Silver Lines MSB Unpainted

Effect of CPA/Impact Side

- Exterior of glass generally stronger than interior (i.e. ball/bag tests on exterior had higher break heights than ball/bag tests on interior).
 - Except for with silver lines
- Paint on exterior weakens glass. Paint has less effect on interior surface (if anything makes slightly stronger).



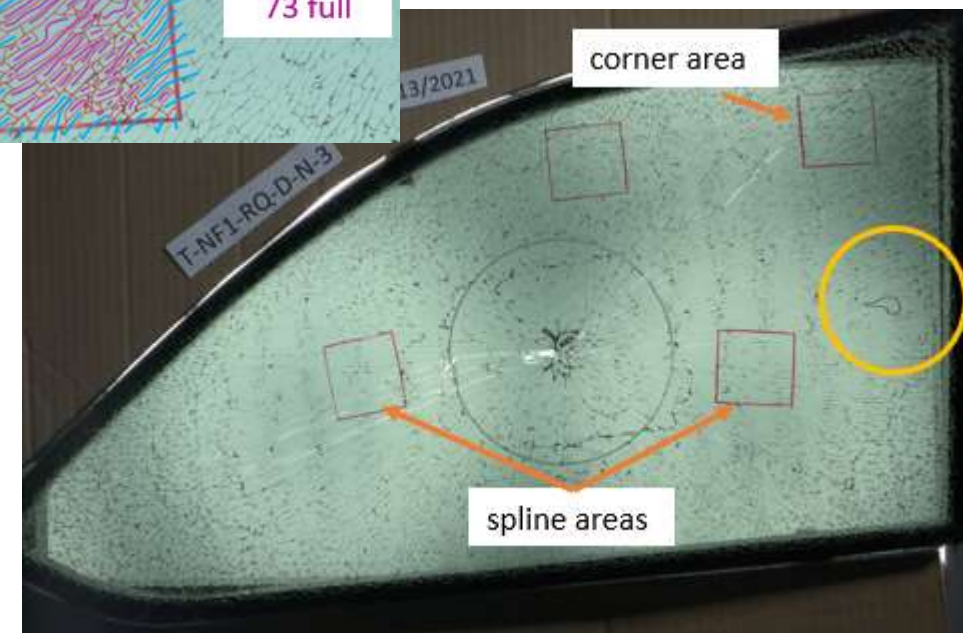
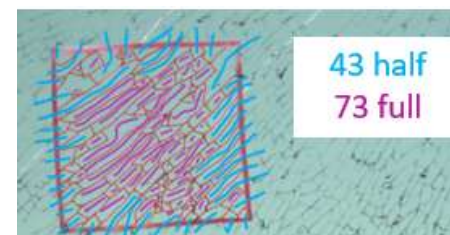
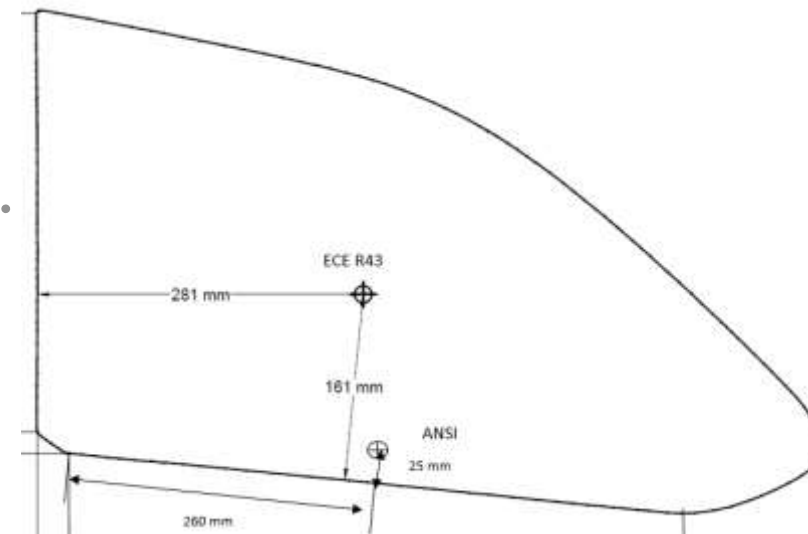
Fracture/Fragmentation

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Fracture Test

- Impact location description
 - ECE R43 point #1 – geometric center
 - ANSI – mid-point of longest edge, 25mm inboard
- Test Criteria
 - Each punch location was evaluated using both the ANSI Z26.1 weight criteria and the ECE R43 count criteria.
 - Both painted and unpainted production glass pieces were evaluated
- Weight description
 - Glass pieces identified between 10 seconds and 3 minutes and outlined for weighing (yellow circle in right image).
 - After 3 minutes identified piece was removed and weighed
- Counting description
 - 5x5 cm squares counted at 2 locations using image collected at 3 minutes post-punch
 - Pieces extending across an edge of square = 1/2 , others = 1



Fracture Test Results

- Average results of 3 tests at each condition
- All tests met both ANSI and R43 criteria at 3-minute timestamp
- Geometric center (ECE R43) location created slightly larger pieces than edge (ANSI) location
- Paint did not have noticeable effect on results



Summary

1. Evaluate various testing situations from ANSI Z26.1 including situations for comparison with ECE R43
 - Compare results from ball test at 10ft (3.1m) and 6.6ft (2m)
 - 6.6ft did not capture weakness of glass at point edge that 10ft drop did. At current standard center location results were equivalent. 71% (10/14 test conditions tested) matched between the heights
 - Compare the standard shot bag to a shot bag with stiffer sidewalls
 - Stiffened bag created more breaks than unstiffened bag, including at the center location (77% match).
 - Stiffened bag concentrates force more causing glass to seem weaker than when impacted with ANSI bag.
 - Examine altered fracture test for tempered glazing with one impact point vs two (ANSI vs ECE)
 - ECE R43 punch location created slightly larger pieces than ANSI punch location

Summary Cont.

2. Evaluate differences in ANSI 12" x 12" flat pieces and matching production parts
 - Sample and production had similar results at center location but different results at other locations in standard height tests (72% match overall – all tempered test modes)
 - In tempered break height tests, samples were similar or slightly weaker than production.
3. Learn about potential changes to tempered glass strength due to ceramic painted area (CPA)
 - When impacted on exterior with ball, CPA weakened glass, especially when impacted at the CPA edge. Silver paint lines also decreased strength. When impacted on interior, paint had little effect and, in some cases, increased strength.



Questions?

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