United States Testing Company, Inc.

5555 Telegraph Road
Los Angeles, CA 90040
Tel: 213-723-7181
Fax: 213-722-8251

REPORT OF TEST

ULTRA BOND, INC.

3696 Beatty Drive, #A
Riverside, CA 92506

REPAIRED LAMINATED GLASS

December 27, 1993

Revised January 10, 1994

TEST REPORT NO. 193128-1R

SIGNED FOR THE COMPANY

BY Michael Beaton

Larry J. Burmer
Project Engineer

Michael Beaton, P.E.
Manager, Engr. Dept.

SGS Member of the SGS Group (Société Générale de Surveillance)

TESTS PROVE ULTRA BOND STRONGER THAN GLASS

Since introducing the now patented crack repair method in February 1990, long cracks have become a "hot" issue in windshield repair. As questions concerning the safety of the process had been raised, Ultra B-O-N-D, Inc. contracted an independent lab to conduct several tests to determine whether a crack repaired using the Ultra BOND process would: 1) restore the structural integrity of the glass; 2) detrimentally affect the lamination; 3) prevent the laminated glass from functioning properly upon impact.

In each of the tests it was proven that a long crack repaired with the Ultra BOND process as described in patent #5,116,441, did not adversely affect the windshield. The results were as follows:

1. Structural Integrity - restored
2. Lamination - No negative effects.
3. Function - Glass performance was the same as original, new glass.

The cracked glass samples were first exposed to water, humidity, natural temperature changes (the environment), placed in a freezer at 10 F, an oven at 150 F, and washed with windshield cleaning fluid. This was to simulate, as close as possible, what a cracked windshield may be exposed to prior to repair. It should be noted that in every impact test the repaired crack remained intact.

In the structural integrity tests, the load on the repaired samples averaged higher than the original glass, and 75% of the time the fracture occurred away from the repair. On the samples that were cracked and not repaired the average load score was lower and 70% failed (gave way) at the crack.

A humidity test performed proved that once a crack is repaired properly there is NO effect on the lamination. Repairing the crack stops and prevents the windshield from delamination and would prevent spalling. It also proved that once the resin was cured there was NO deterioration of the resin from heat and/or humidity. The crack showed no signs of deterioration in the boil test as well.

ANSI/SAE 226.1-1990 test 26 was performed on the specimens after the boil and humidity tests. Results were the same: no spalling or separation occurred at or near the repaired crack and the repaired crack remained intact with no signs of deterioration.

These findings are equivalent to hundreds of field tests that have been on-going since 1989. Both laboratory and field tests corroborate that the Ultra BOND long crack repair process is 100% SAFE. In fact, it is the strongest part of the windshield.

The patented Ultra B-O-N-D, Inc. method (#5,116,441) uses resins of multiple viscosities; meaning, progressively stronger resins are applied as the edge of the crack is approached during repair. Field tests have shown that the resin at the edge must be at least 400 cps or higher for the bond to hold and not deteriorate. The adhesion to the glass must be at least 2500 psi and the tensile strength minimum should be 4000 psi. Ultra BOND's number one selling crack resin is 1800 cps, 3200 psi adhesion and 4200 psi tensile.

Field tests also indicated that most cracks 18 inches and under are clean or cleanable and usually show no signs of delamination. Just the reverse has been found with 24 inch cracks. Ultra BOND, Inc. recommends 18 inches and under and no crack or stone break should be repaired if the lamination is discolored or the crack is dirty, both of which are plainly visible to the technician.

The tests have therefore concluded that cracks 18 inches and under are 100% safe when properly repaired with the Ultra BOND, Inc. process.

For further questions regarding the tests or their results, contact Richard A. Campfield, President of Ultra B-O-N-D, INC. at (800-347-2820)

OBJECTIVE

The purpose of this project was to determine the physical characteristics of the submitted repaired laminated glass by performing impact and penetration tests in accordance with ANSI/SAE Z26.1-1990 and flexural strength tests in accordance with ASTM C 158-84.

REFERENCES

1. Conferences and correspondence with Mr. Richard A. Campfield Commencing November 16, 1993.

2. ANSI/SAE Z26.1-1990, "American National Standard for Safety Glazing Materials for Glazing Motor Vehicles and Motor Vehicle Equipment Operating on Land Highways-Safety Code".

3. ASTM C158-84, "Standard Methods of Flexural Testing of Glass (Determination of Modulus of Rupture)".

SAMPLE DESCRIPTION

The following glass was submitted and identified by the Client as:

A) 33 pieces of 12 inch by 12 inch by 1/4 inch thick repaired laminated glass. Each specimen consisted of two 1/8 inch thick pieces of glass, and contained a repaired crack located on one side of the glass. Some cracks extended from the center to one edge, and some extended from edge to edge.

B) 40 pieces of 10 inch long by 1 2/3 inch wide by 1/4 inch thick laminated glass. Each specimen consisted of two 1/8 inch thick pieces of glass.

a) Twenty each, with a repaired crack which ran across the width of each specimen. Ten of those were marked '6' and ten were marked '8'.

b) Ten each, identified as "original condition" and contained no cracks.

c) Ten each, identified as "cracked and unrepaired".

1. IMPACT, TEST 9 (DART DROP, 30 FT.) PER ANSI/SAE Z26.1-1990

Procedure:

Five, 12 inch by 12 inch specimens were placed individually in the test frame with the repaired side face-up in the frame. The glass was then impacted once from a height of 30 feet using a 7 ounce steel dart. Tests were performed on December 20, 1993.

Requirements:

The dart may crack the glass and may puncture the test specimen. However, the hole so produced in the specimen shall not be sufficiently large to permit passage of the body of the dart completely through the test specimen. Small particles may disengage themselves from both sides of the specimen at and immediately around the point of impact, but no loose or detached pieces shall leave any area of the specimen exclusive of the area puncture by the dart. Furthermore, the glass on adjacent sides of each crack extending from the area punctured by the dart shall be held in place by the reinforcing of strengthening material, and no glass shall be freed from reinforcing or strengthening material for a distance greater than 1-1/2-in (38mm) from a crack. Spalling of the outer glass surface opposite the point of impact and adjacent to the area of impact is not to be considered a failure. No more than one specimen shall break into separate large pieces.

1. IMPACT, TEST 9 (DART DROP, 30 FT.) PER ANSI/SAE Z26.1-1990 (continued)

Results:

For each of the five specimens tested, the dart did not puncture the glass. The glass on adjacent sides of each crack extending from the area impacted by the dart was held in place by the reinforcing material. No specimens broke into separate large pieces. No separation or spalling of glass occurred at or near the repaired crack for each of the five specimens tested.

Conclusion:

The submitted repaired laminated glass met the requirements of Section 9 of ANSI/SAE Z26.1-1990, Impact, Dart Drop, 30 feet.

2. IMPACT, TEST 12 (BALL DROP, 30 FT.) PER ANSI/SAE Z26.1-1990

Procedure:

Twelve, 12 inch by 12 inch specimens were placed individually in the test frame with the repaired side face-up in the frame. The glass was then impacted once from a height of 30 feet using a 0.5 pound steel ball. Tests were performed on December 20, 1993.

Requirements:

The impact may product a large number of cracks in the glass; not more than two of the specimens shall break into separate large pieces. Furthermore, with no more than two of the remaining specimens shall the ball produce a hole or fracture at any location in the specimen through which the ball will pass.

At the point immediately opposite the point of impact, small fragments of glass may leave the specimen, but the small area thus affected shall expose less than 1 in^2 ($645mm^2$) of reinforcing or strengthening material, the surface of which shall always be well covered with tiny particles of tightly adhering glass. Total separation of glass from the reinforcing or strengthening material shall not exceed 3-in^2 ($1935mm^2$) on either side.

Spalling of the outer glass surface opposite the point of impact and adjacent to the area of impact is not to be considered a failure.

2. IMPACT, TEST 12 (BALL DROP, 30 FT.) PER ANSI/SAE Z26.1-1990 (continued)

Results:

For each of the twelve specimens tested, none of the specimens broke into separate large pieces. The ball did not produce a hole or fracture at any location in the specimen through which the ball would pass. At the point immediately opposite the point of impact, the glass remained adhered to the reinforcing material. No separation or spalling of glass occurred at or near the repaired crack for each of the twelve specimens tested.

Conclusion:

The submitted repaired laminated glass met the requirements of Section 12 of ANSI/SAE Z26.1-1990, Impact, Ball Drop, 30 feet.

3. PENETRATION RESISTANCE, TEST 26 PER ANSI/SAE Z26.1-1990

Procedure:

Ten, 12 inch by 12 inch specimens were placed individually in the test frame with the repaired side face-down in the frame. The glass was then impacted once from a height of 12 feet using a 5 pound steel ball. Tests were performed on December 20, 1993.

Requirements:

The impact may product a large number of cracks in the glass and may cause tears in reinforcing interlayer material. The impact furthermore may produce a substantial permanent deformation in the shape of originally substantially flat specimen. However, with no more than two of the specimens shall the ball pass completely through the specimen within a 5-second interval after impact, either by what would be described as a puncture of the specimen or by means of the specimen fracturing into relatively large pieces that subsequently fold aside to permit passage of the ball.

When the specimen is clamped, the specimens during the test exhibiting more than 0.079-in (2mm) of movement at any point along the inside periphery of the frame shall be discarded and a new specimen substituted in its place.

3. PENETRATION RESISTANCE, TEST 26 PER ANSI/SAE Z26.1-1990 (continued)

Results:

For each of the ten specimens tested, the ball did not pass through the specimens. The specimens did not move more than 0.079 inches at any point along the inside periphery of the frame. No separation or spalling of glass occurred at or near the repaired crack. The repaired crack remained intact in each of the ten specimens tested.

Conclusion:

The submitted repaired laminated glass met the requirements of Section 26 of ANSI/SAE Z26.1-1990, Penetration Resistance.

4. FLEXURAL STRENGTH TEST PER ASTM C158-84

Procedure:

Forty, 10 inch long by 1 1/2 inch wide by 1/4 inch thick specimens were placed individually in an Instron Universal testing machine. Five specimens each identified as "6", "8", and "cracked and unrepaired", were tested with the crack in tension (face-down) and five specimens of each sample were tested with the crack in compression (face-up).

The specimens were supported on two bearing edges 8 inches apart. The load was applied through two loading points 4 inches apart and centrally located between the two bearing edges. The load was applied at a constant crosshead rate of compression of 0.50 inches per minute.

Tests were performed on December 20, 1993.

4. FLEXURAL STRENGTH TEST PER ASTM C158-84

(continued)

Results:

Sample: Original condition, containing no cracks.

Specimen Number	Maximum Load (lbs.)	Modulus of Rupture (psi)
1	62	4,200
2	69	4,700
3	60	3,900
4	47	3,200
5	58	3,900
6	73	4,800
7	78	5,000
8	71	4,700
9	62	4,100
10	71	4,600
Average:	64	4,200

Observations:

Failures occurred as a result of one or both layers of glass fracturing. All failures occurred at or between the loading points and ran across the width of the specimens.

4. FLEXURAL STRENGTH TEST PER ASTM C158-84

(continued)

Results: (con't)

Sample: Repaired glass marked "8" - 4,000 cps.

Specimen Number	Maximum Load (lbs.)	Modulus of Rupture (psi)
Repaired crack in compression (cracked side up)		
1	70	4,600
2	67	4,500
3	64	4,300
4	62	4,300
5	72	4,800
Average:	67	4,500
Repaired crack in tension (cracked side down):		
1	67	4,600
2	58	3,700
3	72	4,400
4	70	4,600
5	52	3,400
Average:	65	4,200

Observations:

Failures occurred as a result of one or both layers of glass fracturing. All failures occurred at or between the loading points, and ran across the width of the specimens. Any failures which occurred at the repaired crack occurred after the maximum load of the specimen was reached. In no case did the failure at the repaired crack occur before the maximum load of the specimen was reached. 80% of the failures occurred away from the repaired crack.

4. FLEXURAL STRENGTH TEST PER ASTM C158-84

(continued)

Results: (con't)

Sample: Repaired glass marked "6" - 1,800 cps.

Specimen Number	Maximum Load (lbs.)	Modulus of Rupture (psi)
Repaired crack in compression (cracked side up):		
1	62	3,900
2	63	4,300
3	63	4,300
4	72	4,800
5	55	3,900
Average:	63	4,200
Repaired crack in tension (cracked side down):		
1	74	4,900
2	89	5,700
3	79	5,000
4	62	4,000
5	63	4,100
Average:	73	4,700

Observations:

Failures occurred as a result of one or both layers of glass fracturing. All failures occurred at or between the loading points, and ran across the width of the specimens. Any failures which occurred at the repaired crack occurred after the maximum load of the specimen was reached. In no case did the failure at the repaired crack occur before the maximum load of the specimen was reached. 70% of failures occurred away from the repaired crack.

4. FLEXURAL STRENGTH TEST PER ASTM C158-84

(continued)

Results: (con't)

Sample: Cracked and unrepaired glass

Specimen Number	Maximum Load (lbs.)	Modulus of Rupture (psi)
Crack in compression (cracked side up):		
1	70	5,200
2	47	3,500
3	64	4,700
4	56	4,200
5	62	4,600
Average:	60	4,400
Crack in tension (cracked side down):		
1	51	3,800
2*	--	-----
3	37	2,800
4	46	3,400
5	67	5,000
Average:	50	3,800

Note: Specimen No. 2 was defective and the values disregarded.

Observations:

Failures occurred as a result of one or both layers of glass fracturing. 70% of the failures occurred at the crack.

4. FLEXURAL STRENGTH TEST PER ASTM C158-84
(continued)

Conclusion:

The results of flexural strength tests on the laminated glass sample showed that the glass repaired using the Ultra Bond long crack repair process performed within ± 7% of the original condition glass containing no cracks or repairs.

OBJECTIVE

The purpose of this project was to determine the physical characteristics of the submitted repaired laminated glass by performing humidity and boil tests in accordance with ANSI/SAE Z26.1-1990.

REFERENCES

1. Conferences and correspondence with Mr. Richard A. Campfield Commencing November 16, 1993.

2. ANSI/SAE Z26.1-1990, "American National Standard for Safety Glazing Materials for Glazing Motor Vehicles and Motor Vehicle Equipment Operating on Land Highways-Safety Code".

SAMPLE DESCRIPTION

The following glass was submitted and identified by the Client as:

33 pieces of 12 inch by 12 inch by 1/4 inch thick repaired laminated glass. Each specimen consisted of two 1/8 inch thick pieces of glass, and contained a repaired crack located on one side of the glass. Some cracks extended from the center to one edge, and some extended from edge to edge.

1. HUMIDITY, TEST 3
PER ANSI/SAE Z26.1-1990

Procedure:

Three, 12 inch by 12 inch specimens were placed in a covered container over water for a period of two weeks. The air temperature in the container was maintained between 120°F and 130°F (49°C and 54°C)

Requirements:

No separation of materials shall develop, except for occasional small spots, no one of which shall extend inward from the adjacent edge of the specimen to a depth of more the 1/4 inch (6.35mm).

Results:

No separation of materials occurred. No small spots extending from adjacent edges were observed. No separation or spalling of glass occurred at or near the repaired crack for each of the three specimens tested. The repaired crack remained intact and showed no signs of deterioration.

Conclusion:

The submitted repaired laminated glass met the requirements of Section 3 of ANSI/SAE Z26.1-1990, Humidity.

2. BOIL, TEST 4
PER ANSI/SAE Z26.1-1990

Procedure:

Three, 12 inch by 12 inch specimens were immersed vertically on edge in 150°F water for 3 minutes and then quickly transferred into boiling water. The specimens remained submerged in boiling for a period of 2 hours and then removed.

Requirements:

The glass itself may crack in this test, but no bubbles or other defects shall develop more than 1/2 inch (13mm) from the outer edge of the specimen or from any cracks that may develop. Any specimen in which the glass cracks to an extent confusing the result shall be discarded without prejudice, and another specimen shall be tested in its place.

Results:

No cracks occurred on any of the three specimens tested. No bubbles or other defects were observed. No separation or spalling of glass occurred at or near the repaired crack for each of the three specimens tested. The repaired crack remained intact and showed no signs of deterioration.

Conclusion:

The submitted repaired laminated glass met the requirements of Section 4 of ANSI/SAE Z26.1-1990, Boil.

Appr'd by _____