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COAXIAL DOUBLE RING TESTING OF FLAT GLASS SAMPLES FOR GLASS POLISH IRELAND LTD

(Customer Reference: Ian Bower)

1 INTRODUCTION

On the 23rd of February 2009 Glass Technology Services received 21x flat glass plates for coaxial ring testing.

It was requested that GTS determine the breaking strengths of flat glass in 3 different conditions: pristine; etched; and etched and polished samples. A co-axial double ring bend test was used to determine the surface strengths of the glass.

Samples were prepared on site by Ian Bower and numbered as below: Testing was carried out on the 23rd - 24th of February 2009.

Sample Numbers	Sample condition	Sample Thickness	Notes
A1-A7	Pristine	~6mm	Tested as Received
B1-B7	Etched	~6mm	Samples were Etched with a diamond tipped scribe
C1-C7	Polished	~6mm	Samples were Etched with a diamond tipped scribe and then polished by Ian Bower.

GLASS TECHNOLOGY SERVICES LTD.
9 Churchill Way, Chapeltown,
Sheffield, S35 2PY
Tel: 0114 2901801
Fax: 0114 2901851
E-mail: info@glass-ts.com
Web: http://www.glass-ts.com

2 COAXIAL DOUBLE RING TESTING

2.1 Test Method

The samples were tested using a method based on EN 1288-5:2000 using a Hounsfield Universal Testing Machine with a maximum compressive load of 25kN. The flat glass was covered in an adhesive film in order to retain the glass after testing. After each test the position of failure was identified to confirm a valid test and the glass thickness at the failure origin was measured using vernier calipers.

In the case of the etched and then polished samples (C1-C7), the failure origin thickness was determined using digital micrometers. Four thickness measurements were taken outside the polished region in order to determine the original glass thickness prior to polishing.

2.2 Test Results

Results from the test equipment are recorded in vertical down-force (kN).

2.2.1 Pristine Samples

Sample No.	Force (kN)	Glass Thickness at Origin (mm)
A1	12.99	5.9
A2	17.48	5.9
A3	13.92	5.9
A4	13.73	5.9
A5	14.93	5.9
A6	16.15	5.9
A7	14.00	5.9
Max	17.48	5.9
Min	12.99	5.9
Average	14.74	5.9
StDev	1.57	0.0

2.2.2 Etched Samples

Sample No.	Force (kN)	Glass Thickness at Origin (mm)
B1	8.67	5.9
B2	8.54	5.9
B3	9.34	5.9
B4	9.12	5.9
B5	8.20	5.9
B6	10.31	5.9
B7	8.73	5.9
Max	10.31	5.9
Min	8.20	5.9
Average	8.99	5.9
StDev	0.69	0.0

2.2.3 Etched and Polished Samples

Sample No.	Force (kN)	Thickness at Origin (mm)	Average Original Glass Thickness (mm)
C1	14.42	5.93	5.94
C2[#]	14.66	5.89	5.92
C3[#]	14.45	5.93	5.94
C4[#]	10.35	5.89	5.93
C5[#]	11.85	5.90	5.94
C6[#]	12.15	5.90	5.94
C7	13.16	5.89	5.89
Max	14.66	5.93	5.94
Min	10.35	5.89	5.89
Average	13.01	5.90	5.93
StDev	1.63	0.02	0.02

[#] Note some light etching was still visible on these samples after polishing.

3 INTERPRETATION AND CONCLUSIONS

Summary of Results

	Force at breakage (kN)		
	Pristine	**Etched**	**Etched & polished**
Max	17.5	10.3	14.7
Min	13.0	8.2	10.4
Average	14.7	9.0	13.0
Stdev	1.6	0.7	1.6

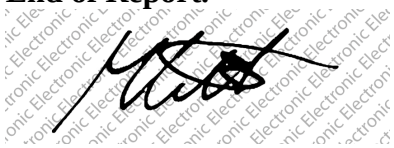
The test method employed causes a uniform bending stress over the surface of the glass, without the weaker edges being stressed. The results collected above therefore represent the magnitude of applied force and is directly proportional to the surface stress at the time of breakage.

- This test data shows that the average strength of the etched glass drops to approximately 60% of the pristine glass.
- Polishing of the etched glass dramatically improves the strength of the etched glass returning it back to near the pristine condition.
- The depth of polishing measured on the test samples set C, was found to be less than 1% of the original thickness.

In theory, toughened (or tempered) glass gains its high strengths from a uniform compressive stress at its surfaces which is approximately $1/5^{th}$ of the thickness. Glass will only fail when in tension, therefore this surface compression must be compromised to produce a breakage, i.e. the etching must penetrate approximately 20% to achieve failure. Similarly, polishing the surface to remove etching must not cut through the compressive layer.

The maximum depth of polishing carried out by Ian Bower was stated as 5% of the original glass thickness which would seem a sensible maximum depth to employ enforcing a suitable safety factor. The results from the tests carried out confirm polishing depths are maintained well within 5% and were found to be less that 1% of the original glass thickness.

End of Report.



Matt Roberts
Principal Technologist

DISTRIBUTION:

Harry Mathews - 1 copy by email
Glass Polish Ireland Limited
15 Bramblefield Walk
Clonee
Dublin 15
Ireland

Please note:

1) *Samples submitted for testing, etc, will normally be disposed of one month after date of reporting results, unless otherwise arranged.*
2) *A greater variation in the test results may be expected over larger sample sizes from a range of moulds or from different manufacturing runs.*
3) *Tests marked with an * are UKAS accredited.*
4) *No responsibility is taken for the accuracy of sampling unless carried out under GTS supervision.*
5) *Opinions and interpretations expressed herein are outside the scope of UKAS accreditation.*