Laminating Technology and Equipment
What is Laminated Glass?

Laminated glass consists of a tough protective interlayer, for example PVB, TPU, EVA, etc bonded together between two panes of glass under heat.

The standard two-ply construction provides resistance to penetration when subjected to attempted forced entry. In multi-ply configurations, laminated glass can even resist bullets, heavy objects, or small explosions.
Existing Laminating Line

Specific current problems of conventional processing:

- High operating costs
  - Losses
- Time consuming
- Floor space requirements
- Quality issues

Autoclave
GTI’s Laminating Concept

The main concept of our process is heating an assembled product in a vacuum (around 0.05 Bar) by using penetrating electromagnetic radiation that heats the adhesive film much more than the glass.
GTI’s Laminating Diagram

There are three main stages in GTI’s laminating process. At the initial stage the film preheats to a higher temperature than both of the glass sheets. This approach allows evacuating/pumping air and water from the film and its surrounding area because the film does not stick to the inside surfaces of the sheets (due to low glass temperature).

Note: The preheating stage can be started at normal pressure, as well.

Water Boiling Point (F) vs. Pressure (Bar)

<table>
<thead>
<tr>
<th>Pressure, Bar</th>
<th>1</th>
<th>0.2</th>
<th>0.1</th>
<th>0.05</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boiling point, T (F)</td>
<td>212</td>
<td>150</td>
<td>115</td>
<td>90</td>
</tr>
</tbody>
</table>
Further heating leads to spreading of adhesion of the film over the glass surfaces because there is no water or air left. This stage is accomplished in a vacuum chamber.

At around 212F (100C) the entire surface of both glass sheets are bonded, however the heating process continues to achieve the necessary adhesion level. This stage is accomplished in vacuum or at normal pressure.
Line Options

Vacuum Laminator

Entire laminating process can be accomplished in laminator.

Preheating Oven + Vacuum Laminator

Or pre-heating in conventional oven and laminating in vacuum laminator.

Vacuum Laminator + Final Oven

Pre-laminating in vacuum laminator and final curing in conventional oven.
Line Option

The laminating process divided in three parts: pre-heating in conventional oven, laminating in vacuum laminator and final film curing in conventional oven.
Vacuum Laminator/Chamber (general view)
Hot-air Oven (general view)
The GTI process is applicable to safety, hurricane, ballistic, fire-rated and other laminated flat glass products, as well as an array of PV products.

- Suitable for clear, coated, mirrored, textured or colored glass in an annealed or tempered state
- Best choice for encapsulating solar modules or for other processes sensitive to pressure and temperature
- Process uses standard films: PVB, EVA and others in standard thicknesses
- Easily processes multilayer and thick laminates
GLS Advantages

- Lower operating costs due to reduced labor, energy, and maintenance requirements
- Increased throughput (2-3x) utilizing the same floor space
- Film is less sensitive to moisture control
- Faster response time
- New product opportunities
- Any type of adhesive film can be used
GLS Customers

Glass laminating companies who:

- Are interested in the reduction of production costs
- expand production capabilities
- want to bring laminating business “in house”
- need to avoid pressure and moisture
- want to replace low performance/expensive thermoset films and liquids with thermoplastic films
Certified Test Results: Boil

Boil Test - Passed

Test Results:

3/16" - 0.010 - 3/16" Interlayer Thickness:

<table>
<thead>
<tr>
<th>Sample</th>
<th>Overall Thickness</th>
<th>Side 1 Thickness</th>
<th>Side 2 Thickness</th>
<th>Interlayer Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boil</td>
<td>0.387&quot;</td>
<td>0.187&quot;</td>
<td>0.188&quot;</td>
<td>0.012&quot;</td>
</tr>
</tbody>
</table>

BOIL TEST / ANSI Z97.1-2004

<table>
<thead>
<tr>
<th>Spec. No.</th>
<th>Overall Thickness</th>
<th>Observations</th>
<th>Test Results</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.387&quot;</td>
<td>No bubbles</td>
<td>Pass</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.396&quot;</td>
<td>No bubbles</td>
<td>Pass</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.397&quot;</td>
<td>No bubbles</td>
<td>Pass</td>
<td></td>
</tr>
</tbody>
</table>

Notes:
1. Acceptance Criteria: No bubbles or defects more than 1/2" from edge or crack.

Conclusion: Meets the boil requirements of the referenced standard.

For ARCHITECTURAL TESTING, INC.:

Andrew O'Neill
Technician
APO: apo/mlb

Scott T. Swaltek, P.E.
Senior Project Engineer
## Certified Test Results: Impact

**Impact test- Passed**

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>Overall Thickness</th>
<th>Side 1</th>
<th>Side 2</th>
<th>Interlayer Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact</td>
<td>0.412&quot;</td>
<td>0.192&quot;</td>
<td>0.191&quot;</td>
<td>0.029&quot;</td>
</tr>
</tbody>
</table>

### Test Results:

**3/16” - 0.030 - 3/16” Interlayer Thickness:**

<table>
<thead>
<tr>
<th>Spec. No.</th>
<th>Test Standard</th>
<th>Thickness</th>
<th>Impact Depth Height</th>
<th>Observations</th>
<th>Test Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ANSI Z97.1-1984</td>
<td>0.412&quot;</td>
<td>12&quot;</td>
<td>No opening</td>
<td>Pass</td>
</tr>
<tr>
<td>2</td>
<td>ANSI Z97.1-1984</td>
<td>0.404&quot;</td>
<td>12&quot;</td>
<td>No opening</td>
<td>Pass</td>
</tr>
<tr>
<td>3</td>
<td>ANSI Z97.1-1984</td>
<td>0.396&quot;</td>
<td>12&quot;</td>
<td>No opening</td>
<td>Pass</td>
</tr>
<tr>
<td>4</td>
<td>ANSI Z97.1-1984</td>
<td>0.412&quot;</td>
<td>12&quot;</td>
<td>No opening</td>
<td>Pass</td>
</tr>
<tr>
<td>5</td>
<td>16 CFR 1201</td>
<td>0.409&quot;</td>
<td>48&quot;</td>
<td>No opening</td>
<td>Pass</td>
</tr>
</tbody>
</table>

1. Acceptance Criteria: No shear or opening through which a 3” sphere can freely pass.

**Conclusion:** Meets the impact requirements of the referenced standard.

For ARCHITECTURAL TESTING, INC.:

[Signatures]

Andrew O’Neill
Technician
APO.cpo/slb

Scott T. Swalick, P.E.
Senior Project Engineer
Certified Test Results: Impact

Passed
Certified Test Results: Pummel

Pummel Test - Passed

August 31, 2005

Ms. Lian Sawires
Gyrotron Technology, Inc.
2814 Ford Road, Unit K
Bristol, Pennsylvania 19007

RE: PUMMEL TEST RESULTS

Dear Ms. Sawires:

Architectural Testing, Inc. (ATI) has completed the pummel test of three samples provided to us by your firm. The table below details the results of the evaluation and the attached photos are for reference to the values.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Side 1 - End 1</th>
<th>Side 2 - End 1</th>
<th>Side 1 - End 2</th>
<th>Side 2 - End 2</th>
<th>Average</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>24</td>
<td>86</td>
<td>82</td>
<td>72</td>
<td>66.0</td>
<td>Middle</td>
</tr>
<tr>
<td>B</td>
<td>60</td>
<td>70</td>
<td>80</td>
<td>20</td>
<td>77.5</td>
<td>Best</td>
</tr>
<tr>
<td>C</td>
<td>82</td>
<td>70</td>
<td>90</td>
<td>40</td>
<td>70.5</td>
<td>Worst</td>
</tr>
</tbody>
</table>

If you have any questions regarding this letter or the information contained herein, please contact me at your convenience.

For ARCHITECTURAL TESTING, INC.

Todd D. Burroughs
Director - Component/Materials Testing
TDB@adtv.com
cc: 59771.01-106-31
Attachments
Photographs

Adhesion is controlled by temperature alone
Flat Glass
Decorative Glass
Curved Glass
Solar Modules Laminated By PVB
Solar Modules Laminated By EVA