UV Cured Fiberglass Ballistic Panels

Dan Montoney
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What is a Fiberglass Ballistic Panel?

Structural panel engineered to provide protection against complete penetration, passage of fragments of projectiles, or spalling (fragmentation) of the protective material to the degree that injury would be caused to a person standing directly behind the bullet resistant barrier.
Fiberglass Ballistic Panels

1) Civilian applications
   a. Government/Public Buildings
      i. Courthouses, public safety, Federal/State/County offices, etc.
Fiberglass Ballistic Panels

1) Civilian applications
   a. Financial Institutions
      i. Banks, credit unions, etc.
   b. Residential
      a. Safe rooms, storm shelters
Fiberglass Ballistic Panels

1) Civilian applications
   d. Commercial
      i. Jewelry stores, convenience stores, pawn shops, pharmacies
   e. Educational Institutions
      i. Grade schools, Universities and Colleges, trade schools
2) How to stop a bullet/blast fragment

a. Panel must absorb and dissipate energy
   i. Mass of panel
   ii. Strength and orientation of woven fibers
   iii. Controlled delamination of individual plys/layers of fiberglass and engineered resin
What is UV/Light Curing?

- The use of specific UV and Visible photon energy to polymerize/cross-link functional resins quickly and efficiently.
  - Epoxy, urethane, polyester, acrylic (meth)acrylates
  - Conventional, Cycloaliphatic Epoxies
  - Unsaturated Vinyl/Polyesters
UV/Light Curing

- Commercially used to cure functional inks, coatings, resins, sealants and adhesives
- Milliseconds – minutes exposure time
- Currently used in numerous composite applications as matrix resin and functional coatings
  - Filament would pipes and tanks, pultrusions, surf boards, cured-in-place pipe, concrete repair
- Staple in printing and wood finishing industries for over 30 years
UV/Light Curing

- Sensitive to color, UV absorption
- Performance competitive vs. conventional polyesters, epoxies, urethanes, phenolics
- Low capital cost/complexity for safety shielding
- Photoinitiator

“Window of Opportunity”
UV/Light Curing

- Ultraviolet light, Visible light = photons
UV/Light Curing Advantages for FRP Ballistic Panels

1) Efficient
   a. Nearly instantaneous cure – fraction of a second to minutes
      i. High throughput/productivity
      ii. Reduced energy consumption
   b. 100% solids single-component resin
      i. High yield, minimum waste
UV/Light Curing Advantages for FRP Ballistic Panels

2) Environmental and User-Friendly
   a. No VOCs/HAPs (phenols, formaldehyde and/or styrene)
   b. No flammability concerns
   c. Single component, no pot-life
   d. Easy cleanup
   e. Application compatibility
UV/Light Curing Advantages for FRP Ballistic Panels

3) Enabling
   a. Useful with heat-sensitive materials
      i. Thermoplastic fibers and films
   b. Controllable cure
   c. Reduced/no emission reporting
   d. Competitive advantage!
Challenges of UV/Light Curing for FRP Ballistic Panels

1) Light penetration
   a) Must be able to completely cure entire panel thickness (from one side or two)

2) Resin costs
   a) Polyesters, vinylesters, phenolics – commodities – ~$1.25-$2.00/lb
   b) UV - ~$3.00/lb+
Challenges of UV/Light Curing for FRP Ballistic Panels

3) Curing under compression
   a) Design unique platens to retrofit current presses
   b) Design integrated UV/light curing technology
UV/Light Curing Ballistic Panels – Technology Development

1) Collaboration between industrial partners and SUNY-ESF’s UV/EB Technology Center
   a) Design, build, and test prototype formulations, equipment, and process(es)
   b) Manufacture 14”x14”x½” finished panels for ballistic testing
   c) Test/qualify per UL and/or NIJ specifications
   d) Scale up to 24”x24”x½” panels and optimize for cost
UV/Light Curing Ballistic Panels – Technology Development Status

1) Designed unique UV transparent platen
   a) Pressure up to 200psi

2) Optimized chemistry and light source/design for maximum penetration/cure

3) Produced 14”x14”x½” panels that were tested per UL 752, Level 3 (0.44 Mag.) – PASSED

4) Now scaling to 24”x24”x½” and optimizing SYSTEM for costs
UV/Light Curing Ballistic Panels – UL 752 Levels

<table>
<thead>
<tr>
<th>Level</th>
<th>Stop</th>
<th>Bullet Type</th>
<th>Velocity (ft/sec)</th>
<th>Shots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>stops</td>
<td>.9 mm.</td>
<td>1,175-1,295</td>
<td>3</td>
</tr>
<tr>
<td>Level 2</td>
<td>stops</td>
<td>.357 Mag.</td>
<td>1,250-1,375</td>
<td>3</td>
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<tr>
<td>Level 3</td>
<td>stops</td>
<td>.44 Mag.</td>
<td>1,350-1,485</td>
<td>3</td>
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<tr>
<td>Level 4</td>
<td>stops</td>
<td>.30 Cal. Rifle</td>
<td>2,540-2,794</td>
<td>3</td>
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<td>Level 5</td>
<td>stops</td>
<td>7.62 mm Rifle</td>
<td>2,750-2,794</td>
<td>1</td>
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<tr>
<td>Level 6</td>
<td>stops</td>
<td>.9mm Uzi</td>
<td>1,400-1,540</td>
<td>5</td>
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<tr>
<td>Level 7</td>
<td>stops</td>
<td>5.56 mm Rifle</td>
<td>3,080-3,388</td>
<td>5</td>
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<tr>
<td>Level 8</td>
<td>stops</td>
<td>7.62 mm Rifle</td>
<td>2,750-3,025</td>
<td>5</td>
</tr>
</tbody>
</table>
UV/Light Curing Ballistic Panels –
~14"x14"x½" Thick
UV/Light Curing Ballistic Panels – Key Questions

- Is it technically feasible? YES
- Is it production worthy? TBD
- Is there an environmental benefit? YES
- Is the capital investment prohibitive? TBD
  - Currently optimizing system design for cost
- Is there a financial case? YES
  - Higher resin costs
  - Increased productivity (30sec-2min vs. 20-45min)
  - Reduced operational costs (labor, utilities, etc.)
Keys to a Successful Evaluation, Qualification and Integration of UV/Light Curing Technology

1) An Open Mind – There is ALWAYS a better way to do something

2) Commitment / Investment – Thoroughly evaluate the technology, not just the “tip of the iceberg”

3) Collaboration with Critical Vendors – Chemistry supplier(s), equipment supplier(s), consultant(s), etc.

4) State and Federal Grants – There are MILLIONS of dollars available to support R&D and integration/adoption efforts for UV/EB

5) Stage-Gate™ or similar NPD/R&D process
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THANK YOU FOR YOUR ATTENTION AND INTEREST

QUESTIONS?

Contact Information:
Dan Montoney
dan@rapidcuretechnologies.com
(888) 847-3610 x701