BULLET PROOF GLASS AND BULLET RESISTANCE BARRIER

BY PREM DUTT
BULLET PROOF GLASS - Meaning

Bullet resistant glass refers to any type of glass that is built to stand up against being penetrated by bullets. Although the public uses the term ‘bullet proof glass’, generally within the industry itself it is referred to as bullet-resistant glass, because there is no feasible way to create consumer-level glass that can truly be proof against bullets.

Bullet proof glass is usually constructed using a strong but transparent material such as polycarbonate thermoplastic and by using layers of Laminated Glass. The desired result is a material with an appearance and light-transmitting behavior of standard glass but offers varying degrees of protection from small arms.
BULLET PROOF GLASS - Through the Ages

1903
Discovery
Edouard Benedictus, a French chemist, drops a flask filled with cellulose nitrate on the ground. While it breaks it does not shatter.

1909
Shatter-Proof Glass Patent Created in France
Benedictus patents his invention in France as "shatter proof glass."

1914
Shatter-Proof Glass Patented in USA
Benedictus obtains the US Patent for his invention.

1915
Bullet Resistant Glass Used in WWI
Used in gas mask eyeholes and fighter plane windows
1920
**Bullet Resistant Glass used in Banks**
Was put in place in bank teller stations, and voice transmission systems allowed patrons to communicate with the tellers.

1930
**First Used in Expensive Cars**
Used in cars, though not widely due to its price.

1953
**Polycarbonates Discovered**
Polycarbonates, a group of clear and easily moldable plastics, were discovered by scientists H. Schnell (in Germany) and D. W. Fox (in the US). As Mr. Fox worked for GE, polycarbonates began to be used in commercial products in the late 1950's.
BULLET PROOF GLASS - Through the Ages

1982
First Patent for Bulletproof Glass
Invented by Jacques Sauret and Gerard Grosse, this was the first patent exclusively for bulletproof glass.

1994
Patent Granted for Modern Bulletproof Glass
Filed by William P. Stephinson, this patent is alternating sheets of slightly flexible glass and polycarbonates.

Period: 1935 till date
Used in Security and Safety Applications (Oval Office, Popemobile, etc.)
Some of these include the Presidential Limousine, the Popemobile, the Oval Office, and the Supreme Court. Now it is widely use in many area.
Advancement

The field of bullet proof glass is constantly developing, and there are a number of military projects underway to create lighter-weight, more defensive forms of bullet proof glass. One of the most promising is the use of aluminum oxynitride in the outer layer, in place of a polymer layer. Aluminium Oxynitride is 4 times stronger than silica glass and 85% as strong as sapphire.

U.S. military researchers are moving quickly to develop this new class of transparent armor incorporating aluminum oxynitride (Trade name: ALON) as the outside "strike plate" layer. It performs much better than traditional glass/polymer laminates. Aluminum oxynitride "glass" can’t defeat threats like the .50 caliber armor piercing rounds using material that is not prohibitively heavy. This more resistant-glass that can be used in military assault vehicles and aircraft.
UNDERSTANDING - BULLET PROOF GLASS

Need to understand

- Bullet
- Glass
- Barrier
WHAT’S INSIDE A BULLET

• Bullets are arranged in three systems:
  – The primer (like a fuse)
  – The propellant (chemical explosive)
  – The bullet proper (tapering metal cylinder)
WHAT HAPPENS WHEN BULLET IS FIRED

- Primer ignites the propellant – (main explosives)
- It generates lot of gas very quickly and gas shoots from the back of bullet and increasing pressure and focusing gun barrier at high speed (300 m/s)
- Gun barrel have spiraling grooves that makes bullet spin it leaves
- A spinning bullet is like gyroscope & it follows straight path
- But due to different force acting on bullet,
- It follows downward curve
KINETIC ENERGY OF BULLET

- Kinetic energy is the energy of motion.
- There are different forms of energy.
- Bullet has translational kinetic energy.
- This depends upon mass (m) and speed (v) of the bullet.
- Kinetic energy = \(0.5 \times m \times v^2\)
- Kinetic energy is directly proportional to the square of speed.
- Two fold increase in speed, kinetic energy will increase by a factor of four.
- Standard unit of kinetic energy is Joule.
- 1 Joule = 1KG x metre\(^2\)/sec\(^2\)
- Bullet proof glass has to absorb kinetic energy.
ENERGY IN BULLET

- Handgun (.38)
- Handgun (9mm)
- Shotgun (12g)
- Rifle (30 carbine)
- Rifle (AK-47)
- AWM sniper rifle
- .50 BMG

Energy (joules)
HOW BULLET PROOF GLASS WORKS

The glass is not elastic (meaning it can’t move much when pushed), so all of the energy from the moving bullet is taken by the glass which exceeds the fracture strength of the glass causing it to shatter.

The first layer of glass may shatter when the bullet hits it, however the next layer of polycarbonate is more elastic so it moves when the bullet hits it which dissipates the energy of the bullet horizontally. This takes the energy away from the bullet slowing it down. If enough energy is taken from the bullet it will eventually stop it from passing through.
PROCESS OF MANUFACTURING

• Bullet Proof Glass’ purpose is to place barrier in front of your body.
• Barrier will dissipate Bullet Energy.
• These are laminated glass, which is a sandwich of Glasses with a inter layer like Poly Vinyl Butyl and Poly Carbonate in between.
• Bullet Glass is thicker (15mm to 70 mm) and is heavy depending upon the threat level.

• Bullet proof glass two type i.e.—Straight or curved glass

• Straight bullet proof glass is easier to make.

• Curved bullet proof glass you have to make mould.

• Bullet Glass is energy absorbing glass.
PROCESS DIAGRAM OF BULLET PROOF GLASS

- Glass after pretreatment
- Lay Up Room i.e., PVB/Glass
- Dearing Process
- Process Parameter Temp 25 degree Celsius & Rh = 25%
- PVB Roll
- Vacuum Process
- Calendar Process (NIP Roller)
- Temperature 135 deg C
- Pressure 12 Bar
- Autoclave
- Quality Checking
- Packaging & Dispatch

GOLD PLUS GLASS INDUSTRY LIMITED
PROCESS OF CURVED BULLET PROOF GLASS

• **STEP 1:** Making of glass moulds –
  – Moulds are an exact copy of curved glass with all curvature and bends. This mould is used in the bending process.

• **STEP 2:** Cutting and layout –
  – To cut the glass as per requirement along with sheet of polycarbonate and polyurethane bonding inter layers.

• **STEP 3:** Glass Bending –
  – Place the cut flat glass as per STEP 2 and set these on moulds in the bending ovens.

• **STEP 4:** Clean room assembly –
  – These bent glasses and layer of polyurethane bending interlayer are assembled in proper configuration.
STEP 5: Vacuum bag assembly –

– After stringent inspection, the full layup is then inserted into vacuum bag and sealed.

STEP 6: Autoclaving –

– These are sent to autoclave and autoclave binds all of layers of polyurethane, glass and bonding interlayers.

STEP 7: Final inspection and packing –

– Curved bullet glass are removed from the autoclave. It is checked against the moulds and original glass to see that glass fit properly. These are packed and ready for dispatch.
Standard EN-1063 classifies two types of weapons: handguns & rifles and shotguns (SG Classes).

There are 9 categories of weapons tested.

Glass is classified as bullet resistance. If it stops all the bullets on three sheets tested.

Also to record if any splinters (S) or (NS) behind the glazing.

Classes BR1 to BR7 contain glasses offering increasing levels of protection. There is no correlation between SG and BR classes.
QUALITY TESTING STANDARD

- Standard EN 1063 – Security Glazing

<table>
<thead>
<tr>
<th>Class</th>
<th>Type of weapon</th>
<th>Calibre</th>
<th>Type of ammunition</th>
<th>Mass of ammunition (g)</th>
<th>Test conditions</th>
<th>Striking distance (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BR1</td>
<td>Rifle</td>
<td>0.22 Long rifle</td>
<td>L/RN</td>
<td>2.6 ± 0.1</td>
<td>10.00 ± 0.5</td>
<td>360 ± 10</td>
</tr>
<tr>
<td>BR2</td>
<td>Handgun</td>
<td>9 mm Luger</td>
<td>FJ/RN/SC</td>
<td>8.0 ± 0.1</td>
<td>5.00 ± 0.5</td>
<td>400 ± 10</td>
</tr>
<tr>
<td>BR3</td>
<td>Handgun</td>
<td>0.357 Magnum</td>
<td>FJ/CB/SC</td>
<td>10.2 ± 0.1</td>
<td>5.00 ± 0.5</td>
<td>430 ± 10</td>
</tr>
<tr>
<td>BR4</td>
<td>Handgun</td>
<td>0.44 Rem. Magnum</td>
<td>FJ/FN/SC</td>
<td>15.6 ± 0.1</td>
<td>5.00 ± 0.5</td>
<td>440 ± 10</td>
</tr>
<tr>
<td>BR5</td>
<td>Rifle</td>
<td>5.56 x 45 *</td>
<td>FJ/PB/SCP1</td>
<td>4.0 ± 0.1</td>
<td>10.00 ± 0.5</td>
<td>950 ± 10</td>
</tr>
<tr>
<td>BR6</td>
<td>Rifle</td>
<td>7.62 x 51</td>
<td>FJ/PB/SC</td>
<td>9.5 ± 0.1</td>
<td>10.00 ± 0.5</td>
<td>830 ± 10</td>
</tr>
<tr>
<td>BR7</td>
<td>Rifle</td>
<td>7.62 x 51 **</td>
<td>FJ/PB/HC1</td>
<td>9.8 ± 0.1</td>
<td>10.00 ± 0.5</td>
<td>820 ± 10</td>
</tr>
<tr>
<td>SG1</td>
<td>Shotgun</td>
<td>Cal 12/70</td>
<td>Solid lead³</td>
<td>31.0 ± 0.5</td>
<td>10.00 ± 0.5</td>
<td>420 ± 20</td>
</tr>
<tr>
<td>SG2</td>
<td>Shotgun</td>
<td>Cal 12/70</td>
<td>Solid lead³</td>
<td>31.0 ± 0.5</td>
<td>10.00 ± 0.5</td>
<td>420 ± 20</td>
</tr>
</tbody>
</table>

* twist length 178 mm approx. 10 mm
** twist length 254 mm approx. 10 mm
1 Plated steel jacket
2 Brass alloy jacket
3 Brenneke slug
L Lead
CB Coned bullet

FJ Full metal jacket
FN Flat nose bullet
HC1 Steel hard core, mass 3.7 g approx. 0.1 g, hardness > 63 HRC
PB Pointed bullet
RN Round nose bullet
SC Soft core (with lead)
SCP1 Soft core (with lead) and steel penetrator (type SS109)
TESTING

• Standard en-1063 specifies striking distance, number of strikes and range for each type of calibre.
BULLET RESISTANT BARRIERS

• Planning bullet resistance barrier
• Need to understand barrier end use ie.,
  – Threat level of the area.
  – Surrounding infrastructure.
  – Type of item transferred across barrier.
• Selecting appropriate glazing
  – Light transmission – material with best light transmission protect upto level 3 out of 8.
  – Strength – does it need to withstand bullet or any other like sledge hammer.
  – Weight – better protection level, glass becomes heavier.
BULLET RESISTANT BARRIERS

• Select the appropriate surrounding material like frames, door, counters, etc.

• Types of bullet resistance barrier
  – Fixed Barrier System
  – Free standing barrier system
  – Slider system
**BULLET RESISTANT BARRIERS**

- **Fixed barrier system**
  - used in convenience stores, pharmacies, simple ticket windows and where there is an active involvement of money..
  - Employees are protected by a pane of bullet glass fixed in bullet resistant frames.
BULLET RESISTANT BARRIERS

• Free standing barrier system
  – Used in banks, theatres, sports stadium & multiple consecutive stadium.
  – To protect, the employees need to use bullet proof glass at certain height and above that ordinary glass can be used.
• Slider system
  – Used for fast food established and other stores which are open for 24 hours.
  – At night, slider system allows the employee to move the glass back and forth as necessary to facilitate business operations.
PROTECTIVE MATERIAL

- Polymers – which are soft and flexible, but if you hit hard, it will instantly become solid.
- This dissipate impact energy by spreading it over a much larger surface and absorbing it.
- Like Dow Corning Deflexion and D30 lab (orange colour plastic) (Non Newtonian Material)
- Composite Kevlar (Dupont) which is 5 times stronger than steel and can withstand bullet.
- Another product developed by Poland, Liquid armor which become solid upon impact (Non Newtonian Material)
APPLICATION OF BULLET RESISTANT GLASS

• Bullet proof glass provides security to:
  – Banks Tellers
  – Jewellery Stores
  – Museums
  – Police/Military
  – VIP Enclosures
  – Podium
  – Armour Vehicles
THANK YOU

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