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featuring:



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PROTECTIVE GLAZING PRODUCTS

www.viracon.com
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Learning Objectives

Upon completion of this program you will be able to:

- Summarize at least two things that happen during a bomb blast
- Name at least one type of test used to simulate a bomb blast
- List the type of glass product used to protect building occupants during a bomb blast

Test Standards / Specifications

- **Government**
 - GSA
 - Department of Defense (DOD)
 - Department of State (DOS)
 - U.S. Army Corps of Engineers
 - Other
- **Commercial Building Industry**
 - ASTM F 1642
 - ISO 16934:2007 (shock tube) & ISO 16933:2007 (arena)
 - Other / Project Specific Requirements

Classification and Performance Levels

- **GSA**
 - Level C Building: 4 psi / 28 psi*msec
 - Level D Building: 10 psi / 89 psi*msec
- **DOD**
 - Minimum ¼" Laminated Glass for Windows less than 32 sq.ft.
 - Specification available at www.protectiveglazingcouncil.org

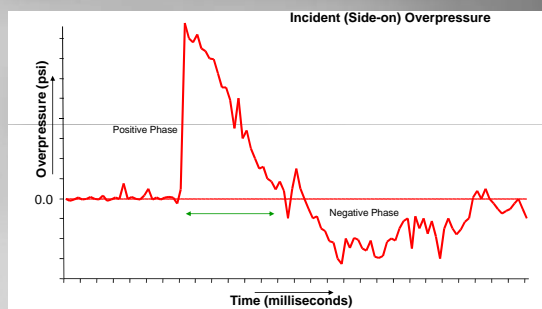
Levels Continued..

- **US Army Corps of Engineers**
 - Level 1: 4 psi/60 psi*msec
 - Level 2: 10 psi/110 psi*msec
- **DOS**
 - Classified, Confidential
 - Higher Blast Levels (40 psi +)
- **Private / Other**
 - Project Specific

AirBlast Sequence

- **Detonation**
- **Enormous Amount of Energy Released**
- **Fireball & Hot Gas Quickly Expands**
- **Shock Wave Propagates**
- **Dramatic Increase in Pressure**
- **Sharp Decline in pressure**
- **Return to Ambient**

Typical Blast Wave



Methods to Evaluate Suitable Glazing Product

- **Blast Test Methods**
 - Arena Test: Actual Blast Event
 - Shock Tube Test
- **Software Simulation Programs**
 - WinGard (Viracon Uses as Reference Tool)
 - AtBlast
 - Others

Testing Methodologies

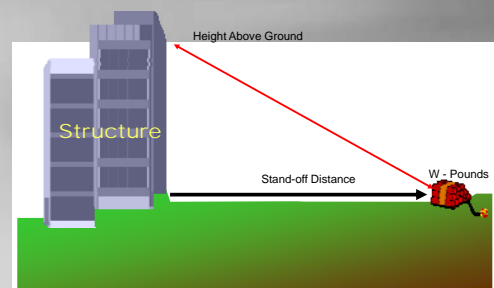
Arena Testing

- Several lites tested simultaneously
- True blast event with negative pressure
- Expensive
- Weather Restrictions

Shock Tube

- Single Lite per test
- Reproducible Shock
- Less Expensive
- Blast not as realistic

Bomb Attack Geometry



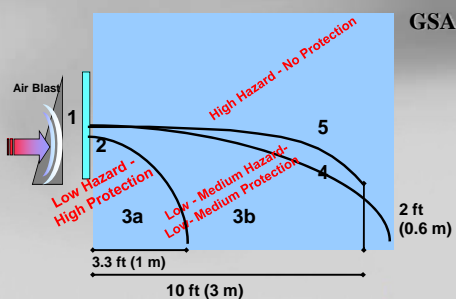
Airblast Resistance

- **Blast Parameters Affecting Glazing**
 - Peak Overpressure
 - Impulse (Duration)
 - Negative Phase
- **Other Blast Considerations**
 - Debris
 - Glass Retentivity

Post Blast Test Analysis

- Blast Information
- Glass Crack / Shatter
- How Much Glass Remained in Frame (Retention by Weight)
- Location of Shards
- Damage to Witness Panel

Injury Hazard Classification



PVB Laminate Response

- Lite cracks as static strength is surpassed
- Laminate deforms inward
- PVB absorbs blast energy as it deflects
- Laminate deters accompanying debris
- Some energy transferred to frame
- Laminate oscillates (neg. phase & elasticity)
- Interior & Exterior protected due to retentivity

PVB Laminated Glass Performance

Monolithic Pvb Laminates:

- **Annealed Glass**
 - 0.030" Interlayer: 16 psi/42 psi*msec
 - 0.060" Interlayer: 20 psi/77 psi*msec
- **Heat Strengthened Glass**
 - Higher initial Break
 - Classification Performance similar to AN
- **Fully Tempered Glass**
 - Must Use Caution - Attachment is Critical

Laminated Glass Performance

- **Low to Medium Performance**
 - *GSA Level C and D
 - *DOD / Anti-terrorism
 - PVB Laminates
 - Insulated PVB Laminates
- **Medium to High Performance**
 - *DOS (Department of State)
 - Enhanced Interlayers
 - Multi-ply Laminates
 - Double Laminated Insulating
 - Glass-Clad Polycarbonates

Blast Resistant Glazing

New Installations:

- ✓ **Standard Laminated Glass**
- ✓ **Nominal 1/4"** (minimum)
- ✓ **Insulating Units 1"** (minimum)
- ✓ **Multi-ply for Higher Security**
- ✓ **Wet Seal to frame**

How to Specify

- Understand Client's Definitions & Priority
- Determine if following a Standard, which one?
- Is a Blast Consultant Involved? = Frame Design
- Determine Blast Load Information:
 - Peak Overpressure - psi
 - Impulse - psi*msec
 - Duration - msec
- or*
- TNT load equivalent
- Standoff distance
- Glass Size



Glazing Considerations

- **Frame Design – Blast Consultant**
 - Frame withstand designed and transferred loads
 - Adequate Frame attachment to the structure
 - Anchoring of laminate into frame – sealant, tape
- Laminated glass is a considered a component of the overall system, therefore; the blast mitigating performance is dependent upon being installed into a an adequately designed frame. Viracon recommends the involvement of a blast consultant to verify the performance of the glass and glazing system combination.*
- **Laminate Configuration**
 - Structural load governs minimum thickness and treatment
 - Interlayer minimum 0.030" (0.76 mm) for AN
 - Recommend 0.060" (1.52 mm) for HS or FT

Bomb Blast in Review

Laminated Glass with PVB

- **High performer in bomb blast protection**
 - Protects building structure, occupants and surroundings
- **Achieves Level 1 -3 of Injury Hazard Guide (GSA & UK criteria)**
- **Nominal 1/4" LAG Wide Application Range**
- **Top choice for New Construction**
- **Retrofit capable and feasible**

... Bomb Blast in Review

Laminated Glass with PVB

- **Resists the impact from debris**
- **Offers high levels of retentivity**
- **Frame/glazing interface can be weak link**
- **Appropriate anchoring critical**
- **Double laminated IGU - Highest Protection**
 - Interior lite may not even break

Learning Objectives Recap

An interactive presentation to:

Define protective glazing products used for specific threat classifications

Identify building codes and standards used in the protective glazing market

Gain an understanding of the characteristics of laminated glass product options and how they perform

Hurricane-Resistant Glass (HRG)



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(800) 533-2080

Learning Objectives

Upon completion you will be able to:

- 1) Create a list of information necessary prior to selecting hurricane-resistant glass
- 2) Explain the hurricane testing process for glazing systems
- 3) Name the difference between large and small missile impact requirements and testing

Importance Beyond Codes



Fort Lauderdale, Florida



Design Considerations

- Determine Applicable Building Code
- Design pressure / wind load
- Large missile or small missile
- Glass size
- Tested / Certified

Building Code History

- 1994 – South Florida Building Code Dade/Broward
- 1996 – SBCCI
- 2001 – IBC
120 MPH wind velocity and higher
- 2004 – FBC
120 MPH wind velocity and higher

Referenced Standards

- ASTM E1996-08 - Windborne Debris in Hurricanes
- ASTM E1886-05 - Cyclic Pressure Differentials

Design Pressure / Wind Load

- Dependent on codes and standards
- Will vary for each project –
can be as high as 200 psf or higher

Large Missile vs Small Missile

- Large Missile 0-30 feet above grade
- Small Missile above 30 feet*

**IBC Code – Small missile is 30-60 ft above grade, except where gravel sources are within 1500 feet. Then, must be above 60', but not 30' above the elevation where the gravel source is located.*

Tested Products

- Miami-Dade – NOA Product Search
– http://www.miamidade.gov/buildingcode/online_product_search.asp
- Component versus System
- Dependant on size

Products Not Yet Tested

- Must be tested as a system glass + frame
- Details to review:
 - Glazing: conventional or structural?
 - Glass Bite: large missile applications typically require 5/8" minimum
 - Anchorage and Hardware requirements



THE TESTING PROCESS

Hurricane Testing

- Missile Impacts – Simulate windborne debris
- Cyclic Wind Pressure Loading – Simulate hurricane winds

Missile Impact Testing

- Refer to ASTM E 1996 for:



- Weight of 2 x 4
- Missile Speed

Missile Impact Test

- Large – Two impacts per system with a 9 lb. 2 x 4 at a speed of 50 ft/sec (34mph)
- Small – Three impacts per system with 10, two gram steel ball bearings at 130 ft/sec (88mph)



Cyclic Wind Pressure Test

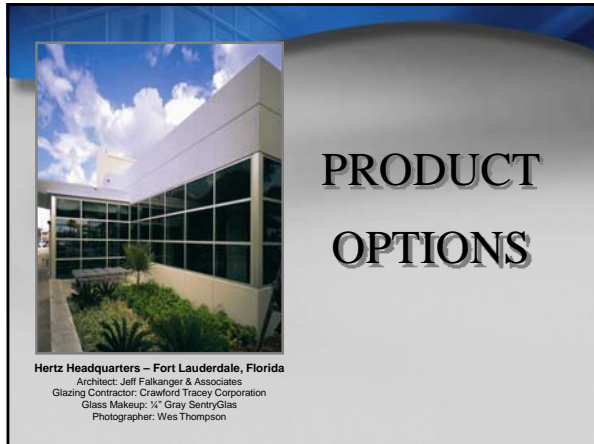


Cyclic Wind Pressure Test

Inward Positive Pressure		Outward Negative Pressure	
Range	Cycles	Range	Cycles
0.2 Pmax – 0.5 Pmax	3500	0.3 Pmax – 1.0 Pmax	50
0.0 Pmax – 0.6 Pmax	300	0.5 Pmax – 0.8 Pmax	1050
0.5 Pmax – 0.8 Pmax	600	0.0 Pmax – 0.6 Pmax	50
0.3 Pmax – 1.0 Pmax	100	0.2 Pmax – 0.5 Pmax	3350

Pass / Fail Criteria

- 3 of 4 systems required to pass
- Opening maximum - 3" sphere (IBC)
- 1/16" x 5" crack (Dade County)
- A system which passes large missile qualifies small missile



HRG Product Options

Design Load / Pressure

- Low – pvb laminates
- Mid – .090 and .100 pvb designed for hurricane applications (more resistant to tearing than pvb laminates)
- High – PET film or glass clad polycarbonate

Low Level Standard PVB

Features –

- Economical

Limitations –

- Restricted to low design pressures and small window sizes

Mid Level Hurricane PVB

Features –

- Minimal deflection
- Available in .090 and .100 thicknesses
- Low to medium design pressures (~90psf)
- Fewer size restrictions
- Can add a translucent interlayer

Mid Level Hurricane PVB

Limitations –

- Not available annealed
- Maximum producible size* - width 72" and length 144"

* Note: Maximum producible size does not imply that the product will pass hurricane testing at the stated size

High Level PET Film / PVB composite

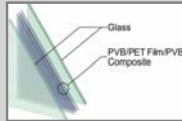
Features –

- Withstands design pressures above capabilities of mid level products
- Less deflection and higher resistance to tearing than PVB alone

High Level PET Film / PVB composite

Limitations –

- Not available annealed
- Current maximum size* is 60” x 144”

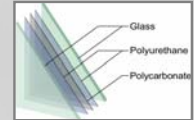


* Note: Maximum producible size does not imply that the product will pass hurricane testing at the stated size

High Level Glass Clad Polycarbonate

Features –

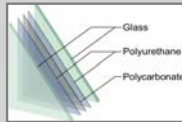
- Highest Performer
- Minimal Deflection
- Tested to Pressures > 200 psf



High Level Glass Clad Polycarbonate

Limitations –

- Higher cost
- Coatings not available on clear glass
- Maintenance and cleaning considerations



HRG Products

- Can be the inboard of an insulating unit
- Available with reflective, low-e and hybrid low-e coatings

Current Code Trends

- ASTM E 1996 – Enhanced Protection for Essential Facilities
- Increase the Large Missile Zone from 0’-30’ to 0’-60’ above grade
- Outside the “High Velocity Hurricane Zone” (HVHZ Dade and Broward) increase the hurricane protection requirements to include the entire exterior shell
- Increase the hurricane protection provisions in the Florida Panhandle from the current 1 mile coastal to the Alabama State line.
- Increase the cladding wind pressure to Category Five (155mph)

Questions ???



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Additional Resources

Viraconsulting™
Website
Product Specification Guides,
Brochures, Tech Talks
SweetSource CD and Sweet's
Website (<http://sweets.com>)



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Owatonna, Minnesota



Join us for the next free webinar
Protective Glazing for Blast Loads
Friday, February 27th at 12 pm ET

featuring:



R.C. (Raj) Goyal
Architectural Testing, Inc.