

Building Restoration for Hurricane Impact or Blast Mitigation

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PRESENTATION OVERVIEW

- Hurricane Mitigation Design
 - Testing Protocol
 - Large Missile
 - Small Missile
 - Cycling Requirements
- Blast Mitigation Design
 - Standards and Ratings
 - Arena Testing
 - Shock Tube Testing
- Multiple Threat Case Study: Bennett Federal Building
- Background on PGC International
- SWRI Opportunities, Member Benefits, and Collaboration



SAFETY vs. SECURITY

Safety = refers to freedom from the risk OR occurrence of injury/loss from natural cause

Security = refers to freedom from the risk OR occurrence of injury/loss from the intentional actions of mankind



BARRIER / FORCED EXIT RESISTANT

Standard construction two-ply laminates with 0.060" interlayer

- Provides layers of significant barrier to penetration resistance:
 - Institutional (i.e.: human, furniture impact)
 - Detention Glazing (i.e.: pry tools, safety equipment)
- Laminated architectural glass (LAG) provides a measure of time for assessment and action.
- Impact resistance (penetration) is directly related to the % of interlayer in the laminate and number of layers of glass.



Figure 2.5 - ASTM F1233 Main-Force-Entry Test Sequence

Test Implements	Class I	Class II	Class III	Class IV	Class V
Blunt Impact (Impacts):					
Sledge Hammer (25)	NR	5	10, 16	15, 22, 27	30, 33, 36, 39
4" (102 mm) Pipe/Sledge (25)	NR	NR	9	18	29
Blunt (15)	NR	NR	8	17	28
Ball-peen Hammer (15)	1	2	NR	NR	NR
Sharp Tools (Impacts):					
Ripping Bar (15)	NR	7	12	23	NR
Chisel/Hammer (25)	NR	NR	13	25	35, 40
Angle Iron/Sledge (25)	NR	NR	15	NR	NR
1-1/2" Pipe/Sledge (25)	NR	3	NR	NR	NR
File A# (25)	NR	NR	NR	24	32, 38
Wood-splitting Maul (25)	NR	NR	NR	21	34, 41
Thermal Stress (Minutes):					
CO ₂ extinguisher	NR	4	NR	NR	NR
Propane Torch (5)	NR	6	11	20	31
Chemical Deterioration (Amount):					
Gasoline (1/2 pt.)	NR	NR	14	NR	NR
Acetone (1/2 pt.)	NR	NR	NR	28	37
Total Test Sequence					
	1	7	16	27	41

Class descriptions characterize the level of protection which a specific glazing can be expected to provide when it successfully completes the stipulated sequences of test attacks. For example, Class I Status is achieved after resisting penetration from 10 blows with a ball-peen hammer. Class II requires resistance to a total of seven attack sequences, including sledge hammer, pipe/sledge, ripping bar, and hot and cold thermal stress.

2. NR indicates specific test "not required" for this class.

3. Chemical deterioration by gasoline and acetone is not expected to affect glass specimens in any significant manner.



Courtesy of Saflex, a unit of Solutia Inc.



SYSTEM TESTING PROTOCOL

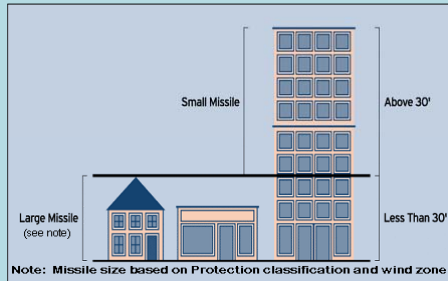
- Impact testing
- Cycling testing
- Forced entry testing
- Air, Water and Structural
- Three out of four identical units must pass Impact & Cycling
- One unit must go through air, water and structural



Courtesy of Saflex, a unit of Solutia Inc.



HURRICANE GLAZING ZONES



Note: Missile size based on Protection classification and wind zone

Courtesy of Saflex, a unit of Solutia Inc.



LARGE MISSILE PROTOCOL

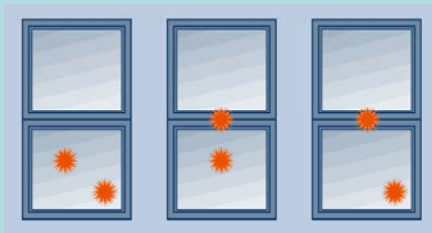
- Used for residential and commercial
- Required: Grade level up to 30 feet
- 2 x 4 inch stud used
- Simulates heavy flying objects: roof tile, timbers, etc
- Must survive 2 impacts at 50 feet/per second (34mph)



Courtesy of Saflex, a unit of Solutia Inc.



TYPICAL IMPACT LOCATIONS

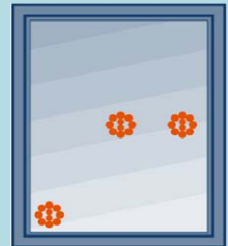


Courtesy of Saflex, a unit of Solutia Inc.



SMALL MISSILE PROTOCOL

- Three shots of 10 missiles
- 2 gram steel ball
- 130 feet/per second (88 mph)
- 30'-60' ASTM
- 30' and up Dade



Courtesy of Saflex, a unit of Solutia Inc.



CYCLING REQUIREMENTS

- Simulates prolonged and shifting winds
- 9000 Cycles



CYCLIC PRESSURE LOADING

Inward-Acting Pressure (positive)

Range	Cycles
0.2P max – 0.5P max	3,500
0.0P max – 0.6P max	300
0.5P max – 0.8P max	600
0.3P max – 1.0P max	100
Total:	4,500

P max is the design wind pressure from the building code, based on an unbreached building envelope



CYCLIC PRESSURE LOADING

Outward-Acting Pressure (negative)

Range	Cycles
0.3P max – 1.0P max	50
0.5P max – 0.8P max	1,050
0.0P max – 0.6P max	50
0.2P max -- 0.5P max	3,350
Total:	4,500

P max is the design wind pressure from the building code, based on an unbreached building envelope



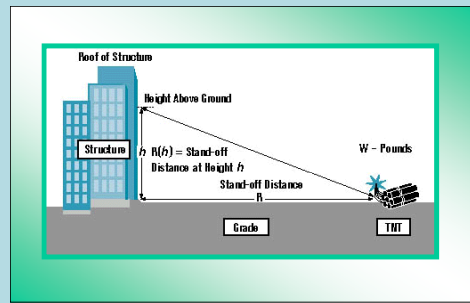
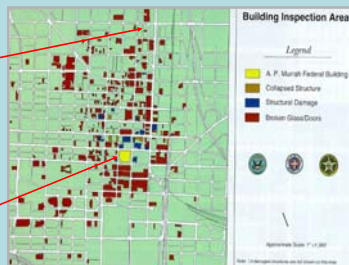
BLAST

- Bomb Blast Events are common
- Glass part of terrorist's arsenal
- Flying glass shards major contributor to injuries
- Blast wave damage upon penetrating the building
- Interlayers in Laminated Glass have been tested for common and extreme blast levels



WHY PROTECTIVE GLAZING?

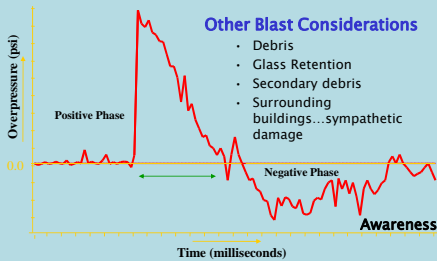
- Broken glass up to 18 blocks away
- Blast event area



Courtesy of Saflex, a unit of Solutia Inc.



BOMB BLAST BASICS A Chronology of a Blast Event



Courtesy of Saflex, a unit of Solutia Inc.



CLASSIFICATION / PERFORMANCE

GSA Levels

- Level C Building 4 psi /28 psi*msec
- Level D Building 10 psi/88 psi*msec
- Based on 44" x 66" opening

Other Government/Private Sector

- UFC: 6 psi/ 42 psi*msec
- DoS: 42 psi/260-300 psi*msec
- ASTM: Levels not provided



STANDARDS / SPECIFICATIONS

Test Methods

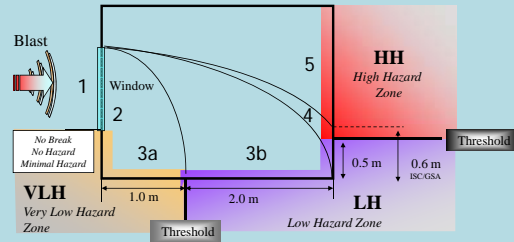
- ASTM F 1642
- GSA/ISC-TS01-2003
- ISO 16933 (arena)

Related Documents

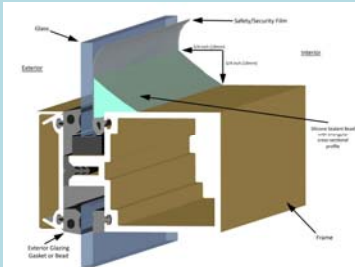
- UFC – Unified Facilities Criteria
- AAMA 510 - Voluntary Guide Specification for Blast Hazard Mitigation for Fenestration Systems
- ASTM F 2248 - Specifying an Equivalent 3-second Duration Design Loading For Blast Resistant Glazing Fabricated with Laminated Glass
- ASTM C 1564 - Use of Silicone Sealants for Protective Glazing Systems



BLAST PROTECTION / HAZARD RATING



PROTECTED WINDOW



UNPROTECTED WINDOW

- 1/4" Tempered Glass on inner and outer lites
- 1/2" Air Gap
- 8 mil. film thickness
- 600 lbs Ammonium Nitrate & Fuel Oil (ANFO) equivalent to 500 lbs TNT
- Standoff Distance: 165 ft
- Total window size: 48" x 66"
- Commercial aluminum frames
- GSA standard protocol: GSA- TS01-2003
- Peak Pressure: 4.43 psi
- Positive Impulse: 30.34 psi-msec



Video courtesy of Tremco, Inc. and CPFilms, a unit of Solutia Inc.



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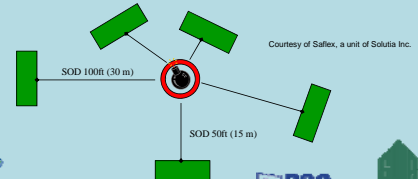
Video courtesy of Tremco, Inc. and CPFilms, a unit of Solutia Inc.



TESTING METHODOLOGIES

Arena Testing

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



TESTING METHODOLOGIES

Shock Tube Testing

- Method of testing structural response of windows and walls to blast loads typical of large explosions
- Testing conducted in steel enclosure called shock tube
- Compressed air used to reproduce explosion with less cost and less potential damage
- Air is released in an impulse wave similar to that of explosive blast positive phase
- Impulse wave travels down the chamber and impacts test specimen
- Difficult to emulate the negative phase



TESTING METHODOLOGIES

Shock Tube Testing



POST BLAST ANALYSIS

- Blast Information
- Glass Crack / Shatter
- Glass Retention / Opening
- Location of Shards
- Damage to Witness Panel



CASE STUDY

Charles E. Bennett Federal Building



CASE STUDY

Charles E. Bennett Federal Building

- Located in Jacksonville Florida, built in 1966, an 11-story building made with pre-cast concrete panels with punched openings for windows.
- Dual challenge of designing for blast and hurricane protection.
- Complete gut, remodel and modernization; replacement of all exterior windows, and abatement for lead paint and asbestos.

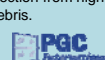


CASE STUDY

Charles E. Bennett Federal Building



- One of the original 1,300 windows which leaked.
- Glass originally specified consisted of uncoated, non-high performance glazing product.
- As a federal building, new windows required to meet improved level of protection from hazards of flying and falling glass.
- Building also located in hurricane-prone area requiring new glass to provide protection from high winds and flying debris.



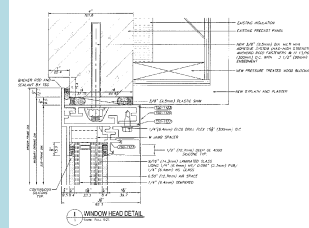
CASE STUDY Charles E. Bennett Federal Building



- Window system designed specifically for project by TSG Industries, Inc.
- Engineering for framing and anchoring system done by Curtainwall Design & Consulting, Inc.



CASE STUDY Charles E. Bennett Federal Building



- Project required both blast resistant windows and storefront.
- Components including strength of anchors, number of fasteners, size and frequency of fasteners, identified through use of WINGARD software tool and finite analysis.



Courtesy of TSG Industries, Inc.



CASE STUDY Charles E. Bennett Federal Building



- Laminated glass specified for performance related to blast mitigation and impact-resistance for hurricane protection.
- Glass laminator and architects upgraded the glass specification to provide better thermal performance, energy control, UV protection, and sound transmission control.



CASE STUDY Charles E. Bennett Federal Building

- Glazing consisted of 1 5/16" laminate which meets large missile requirements
- Included a 1 5/16" insulating PVB laminate which meets small missile
- Structural sealant used to glaze windows in-plant
- Windows delivered to job-site for installation



HISTORY of PGC International

- Incorporated in 1997 in Washington, D.C.
- Formed to address the growing need for protective glazing systems by the General Services Administration and other government agencies, as well as in general construction in the United States



OUR MEMBERS

- Glass Fabricators
- Suppliers of materials and accessories
- Window Film manufacturers
- Curtain Wall and Window manufacturers
- Sealant suppliers
- Consultants and Architects
- Contractors and Engineers
- Test Laboratories
- Fenestration Industry Organizations
- Trade Associations



MISSION STATEMENT

Engage PGC International's active, diverse membership:

- To promote implementation of standards and performance criteria by government and industry
- To identify and promote programs that encourage the use of protective glazing technologies
- To promote the growth of the protective glazing market
- To encourage and promote the development of emerging protective glazing technologies and techniques



PURPOSE STATEMENT

PGC International is the industry advocate influencing the development of protective glazing standards and performance criteria while providing guidance to the government and the private sector.



PGC International Resources: Website



PGC International Resources: Website



SWRI OPPORTUNITIES

- Better understanding of products and installation requirements where hurricane impact or blast mitigation is specified
- Closer insight to protective glazing market opportunities (federal projects, coastal regions, etc.)



SWRI OPPORTUNITIES

- Networking with specialty contractors who often sub installation of sealant, film, mechanical attachments, etc.
- Training and education opportunities (mock-up test requirements, building codes, QC procedures, etc.) where protective glazing is specified



MEMBER BENEFITS

- Two annual meetings
 - Spring Meeting
 - Committee task group meetings focus on membership association development
 - Technical, Liaison, Resources and Marketing Committees
 - Annual Symposium
 - Two-day event with a series of speakers giving presentations relevant to newest trends in protective glazing industry
 - Virtual Tradeshow
 - Held in Washington, D.C. area to attract local government and building code officials, architects and specifiers
- Informational papers & videos
 - Provided by PGC International members and available on website



MEMBER BENEFITS

- E-News
 - Quarterly newsletter that provides information on the council's upcoming events, press releases and industry headlines
- Knowledge & Information Sharing
- Represent the industry to Government organizations, educational institutions, architects, and other related trade associations
- Website Profile



COLLABORATION

Examples:

1. Tremco and CPFilms joint blast testing of IG and monolithic windows. Joint marketing of materials for use in these applications.
2. Tremco, Curtainwall Design & Consulting, Solutia, Oldcastle, Viracon, Prelco, and YKK joint curtain wall blast test.
3. Applied Research Associates and the General Services Administrations work on the Firefighter Ingress-Egress Tutorials.



COLLABORATION



COLLABORATION



COLLABORATION



For More Information...



Please visit our website
www.protectiveglazing.org

