
Des Moines Federal Building IA

WAUSAU
WINDOW AND WALL SYSTEMS

Protective Window Design

Behavioral Care
Blast, and Hurricane

An AIA-CES Program

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Protective Window Design

Behavioral Care
Blast, and Hurricane

(A Wausau AIA-CES Presentation)

PROGRAM SPECIFICS

Length: One hour
Credits: 1 learning unit (LU)/HSW
Cost: Free - There is no cost to bring this program to your firm or chapter meeting, or to take the online course
Description: This program provides an overview of behavioral, blast and hurricane windows. Recommendations for specifications and application are given, along with a review of industry standards, codes and test methods.
Objective: The program is intended to give designers and specifiers an understanding of design criteria for protective glazing systems, testing and certification requirements, applicable codes and standards, as well as appropriate specification provisions.
Point of Contact: For more information or to schedule a presentation, contact Wausau at info@wausauwindow.com or call toll-free at 877.678.2983

FGIA Fenestration & Glazing Industry Alliance

U.S. Green Building Council Member

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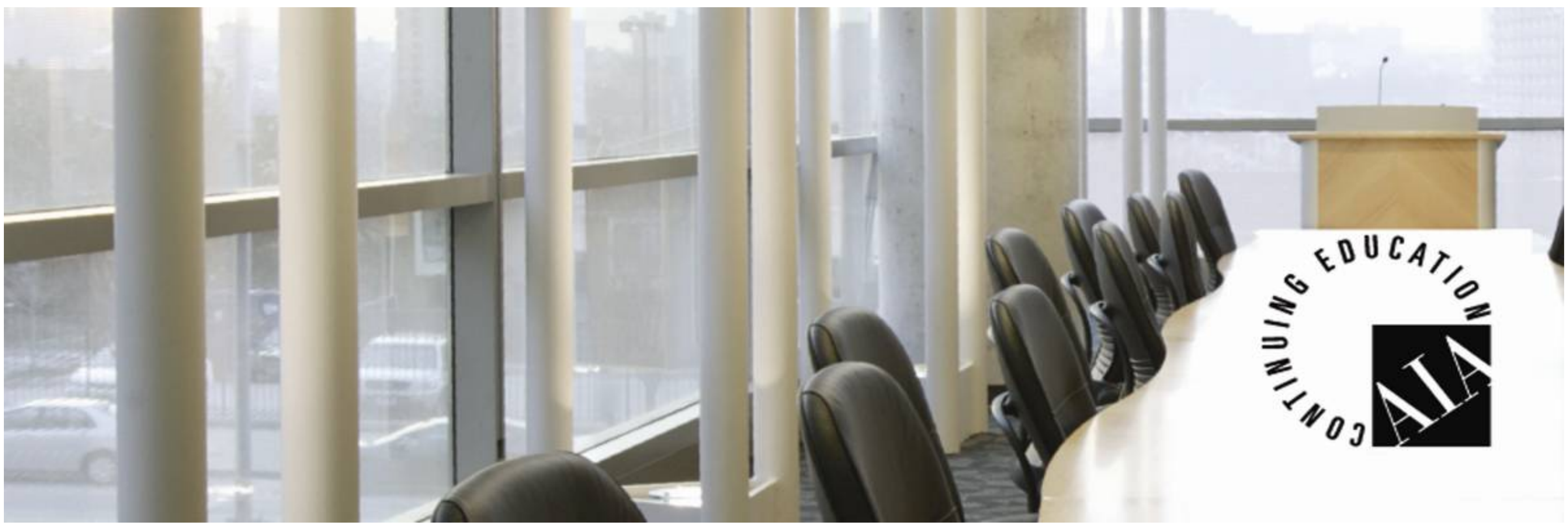
Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

PROTECTIVE WINDOW DESIGN
Behavioral Care, Blast and Hurricane

Learning Objectives

1. Develop design criteria for protective glazing systems
2. Understand testing and certification requirements
3. Understand applicable codes and standards
4. Define performance requirements for specifications



Section One

Behavioral Health

and Human Impact Drop Testing

Behavioral care, blast hazard mitigation and hurricane impact share a common vernacular – that of energy absorption.

Windows for Behavioral Healthcare Applications

Saint Elizabeth's Hospital - Washington, DC

Minimize risks to patients and hep ensure staff safety, while maintaining a therapeutic environment.

Operable windows can provide emergency ventilation in patient rooms. Between-glass blinds can provide occupant-controlled exterior privacy and a sense of control.

Window system selection is an important consideration in creating a modern, healing environment - whether replacing a dated, inefficient facility or renovating a historic mental health institution.

Patients, doctors and medical staff agree that views and daylighting help reduce hospital stays, increase patients' sense of well-being, and expedite the healing process.

"The built environment, no matter how well designed and constructed, cannot be relied on as an absolute preventive measure. Staff awareness of the environment, the latent risks of that environment, and the behavior risks and needs of the patients served in the environment are absolute necessities…"

The Facility Guidelines Institute (FGI/AIA) 2019
"Guidelines for Design and Construction of Hospitals"

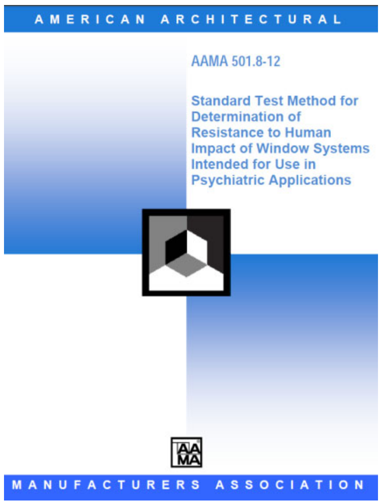
Risk Assessment

Use engineering judgment and experience, supplemented by in-depth input from treatment and security staff at the specific facility. Every facility's policies and patients are different.

An individual institution's assessment of risk is based on any number of factors, including but not limited to:

- Patient population being served - adults, adolescents or children
- Severity of symptoms and underlying behavioral issues
- Admission screening potential
- Patient supervision and policies governing staff intercession and medication
- Control of patients' access to various types of objects
- Interior material flame spread and smoke-generated indices
- Fire fighters' access and/or barricaded room access
- Need for exterior courtyard windows to be resistant to hurled objects

Human Impact Drop Testing


AMERICAN ARCHITECTURAL

AAMA 501.8-12

Standard Test Method for Determination of Resistance to Human Impact of Window Systems Intended for Use in Psychiatric Applications

AAMA

MANUFACTURERS ASSOCIATION

In 1983 the New York State Office of Mental Health (OMH) proposed changes in disruptive patient intercession protocols for State "psychiatric" facilities; establishing both prescriptive and performance requirements, including human impact testing.

In 2008 OMH announced more-stringent U-Factors and 2000 ft-lb impact testing for new behavioral care upgrades.

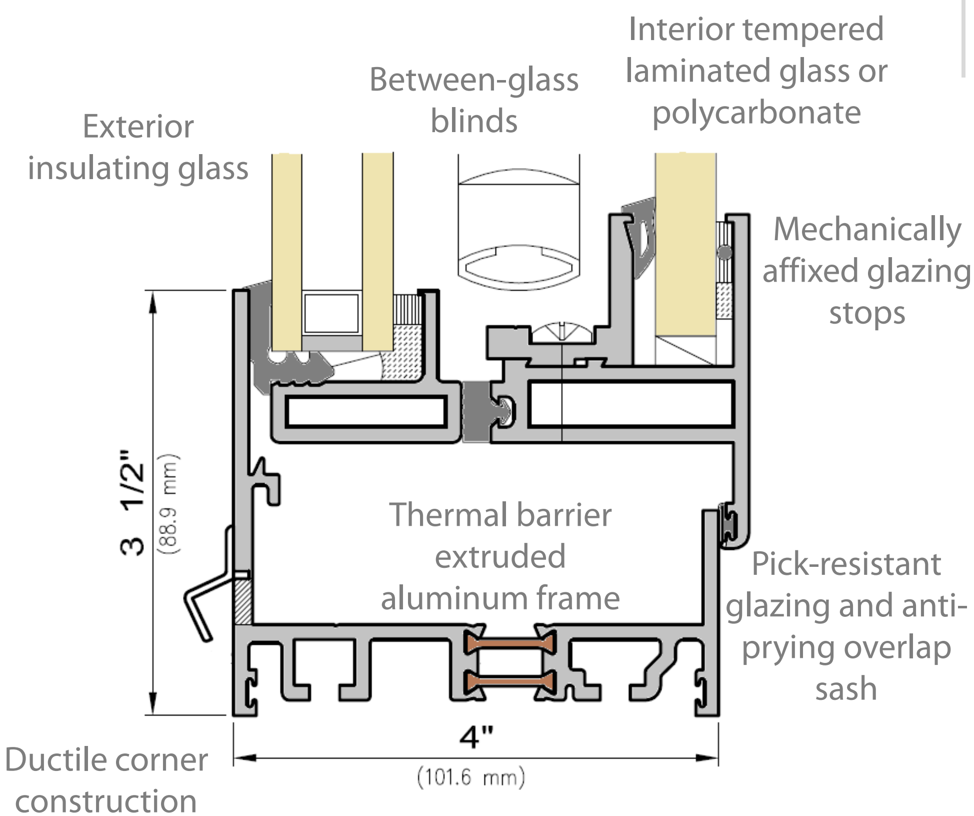
If a patient runs into the window, strikes the window, or throws an object against the window, energy must be transferred sequentially through hardware, window frames, anchorage and substrates.

A human impact is typically considered "worst case," imparting as much as 2,000 foot-pounds of energy, based on the shoulder impact of a 200-pound person moving at 25 feet per second.

This can require 1/2" thick polycarbonate or 7/16" tempered laminated glass for interior glazing.

Seldom will standard windows fitted with safety glass or polycarbonate be considered sufficient, as interior glazing infill deflects upon impact and may disengage from the standard window frame.

Window Evaluation



This behavioral care in-swing casement window sill detail illustrates some key design features

Evaluation of window products for behavioral health applications may include resistance to, or restriction of:

- Escape attempts or passage of contraband
- Patient access to unauthorized areas or potential routes of egress
- Attack to window components using blunt or sharp objects
- Tampering with, or disabling, locking devices
- Laceration or self-harm by cutting
- Pica behavior (ingestion of components, materials or coatings)
- Abrasion, prying or cutting of framing materials, glazing or hardware
- Weapon-ization of parts that could be removed from window assemblies
- Ligature

Human Impact Drop Testing
(continued)

Play video

In 2012, AAMA published AAMA 501.8, making the time-proven OMH test protocols an industry standard.

AAMA 501.8 validates the human impact aspect of security for the total behavioral care window system, including glazing, anchors and hardware, through laboratory testing

A weighted impact device is utilized to apply a force simulating a patient running full-speed into the window

At the conclusion of testing the window system shall be deemed to pass the test if specific post-impact safety, security and enclosure conditions are met

Codes and standards vary widely with jurisdiction, so consultation with on-site medical and security staff is encouraged in determining appropriate resistance and necessary security

Window Features

Integral between-glass blinds reduce solar heat gain, offer privacy control without the potential dangers of exposed cords, and minimize maintenance

Concealed hinges and tamper-resistant hardware are featured, with keys non-removable in the unlocked position

Supplemental Gematic™ locks enhance the perception of security

With operable windows, custodians may clean exterior glass surfaces from the interior, and quickly vent nasty smells or noxious fumes. In the rare case of a fire, facilities with operable windows have the option of venting smoke and aiding egress or rescue.

Either prime windows or interior accessory windows may be utilized in behavioral care applications

Specification Recommendations

In-plant water testing on a statistically-valid sampling of glazed windows helps ensure field performance equal to the laboratory

Impact tests at maximum size as well as minimum "short dimension" are recommended, whether standard product or job-specific testing.

Meeting rails and stacking mullions must be included in test units if used on the project.

Require glazing bead fastener thread engagement of 0.250", or other connection developing full fastener strength.

Shop drawings and structural calculations by the manufacturer validate adequacy of anchorage provisions upon impact.

Consult with treatment professionals, security staff and facilities management before finalization.

Online Resources


Office of Mental Health

Patient Safety Standards,
Materials and Systems Guidelines
Recommended by the
New York State Office of Mental Health

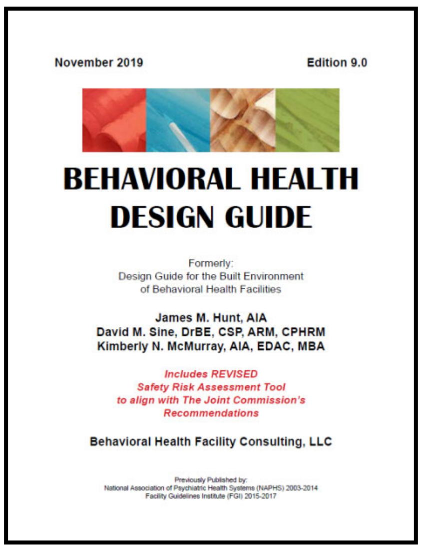
With respect to NYS-OMH operated facilities, these Guidelines apply solely to new construction and major renovation projects. Existing facilities should use these Guidelines as a reference document whenever they make improvements.

20th Edition | August 15, 2018

Developed in association with architecture+

"New York State Office of Mental Health's Patient Safety Standards, Materials and Systems Guidelines"

- Researched and maintained by Lomonaco and Pitts, P.C. doing business as **architecture+** of Troy, New York.


November 2019 Edition 9.0

BEHAVIORAL HEALTH
DESIGN GUIDE

Formerly:
Design Guide for the Built Environment
of Behavioral Health Facilities

James M. Hunt, AIA
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Kimberly N. McMurray, AIA, EDAC, MBA

Includes REVISED Safety Risk Assessment Tool to align with The Joint Commission's Recommendations

Behavioral Health Facility Consulting, LLC

Previously Published by:
National Association of Psychiatric Health Systems (NAPHS) 2003-2014
Facility Guidelines Institute (FGI) 2015-2017

"Behavioral Health Design Guide"

- Distributed by Behavioral Health Facility Consulting, LLC
- (formerly distributed by the National Association of Psychiatric Health Systems)


BRAC 133 Mark Center . Fort Belvoir, MD

Section Two

Blast Hazard Mitigation

Blast Hazard Basics

As the extreme pressure released by an explosive mass encounters windows and curtainwall, all elements of the assembly must work together.

Modern, blast-mitigating assemblies are intended to be flexible and absorb blast energy.

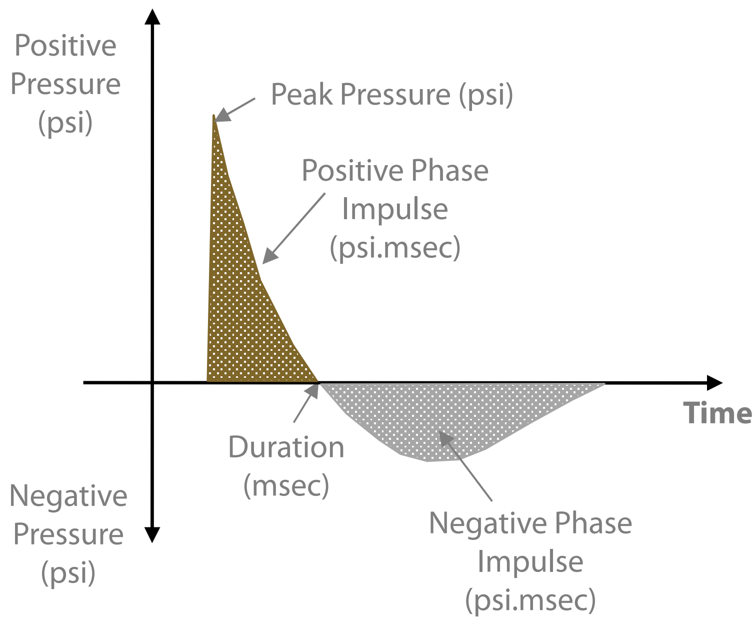
The objective: Protect building occupants and minimize the potential for progressive building collapse. A building's exterior is the first and primary line of defense.

There is no such thing as a "blast proof" window. The term "blast hazard mitigating" (BHM) is used to establish a level of expected protection based on the professionally assessed threat potential.

Windows generally represent the weakest link in the building envelope, and glass has caused the most injuries in benchmarked blast events.

Windows are also the most-readily upgraded of the building envelope elements, often giving the most value for protection investments, creating elegant, quiet, daylight-filled, environmentally-responsible, and safe buildings.

The Blast Shock Wave



An open arena blast test

Blast load is usually quantified as an inter-related combination of peak pressure (psi) and impulse (psi.msec)

Peak Pressure: The maximum overpressure of the initial air shock wave measured in pounds per square inch (psi)

Duration: The time required for the initial pressure to return to zero (msec)

Impulse: The area under the pressure-time curve = 0.5 x duration x peak pressure

Requirements can range from 4 psi-28 psi.msec to 10 psi-89 psi.msec or higher.

In some occupancies such as embassies or law enforcement centers, ballistic resistance and/or force protection performance requirements are also advisable.

Department of Defense (DoD)

Anti-Terrorism Force Protection (ATFP) Standards

Shepard Hall - Joint Base Andrews, MD

DoD standards are frequently cited by Naval Facilities Engineering Command (NAVFAC), the US Army Corps of Engineers (USACE), the General Services Administration (GSA), the National Aeronautics and Space Administration (NASA), and other government agencies.

The primary standard for blast design is the DoD Unified Facilities Criteria UFC 4-010-01 dated 18DEC18, *"DoD Minimum Anti-Terrorism Standards for Buildings."*

The Unified Facilities Guide Specification (UFGS), maintained and applied using SpecsIntact™ software is often employed by government sector specifiers.

The Veterans Administration Physical Security Design Manual also offers guidance for specifiers.

Know which standards are applicable to the specific project in question.

The Whole Building Design Guide (WBDG) acts as a central source for access to these documents. Detailed engineering tools and software may be subject to limited-access restrictions.

UFC 4-010-01 18DEC2018

"DoD Minimum Anti-Terrorism Standards for Buildings."

Shepard Hall - Joint Base Andrews, MD

Less stringent prescriptive blast design requirements for glazing apply to certain building with no identified threat. However, laminated glazing in compliance with UFC Section 3-11 Standard 10 is always required to minimize hazardous glazing fragments.

Airblast peak loads and impulse for windows are now determined from a "Design Threat Analysis," which considers:

1) Charge weight (I or II), and
2) Standoff distance

Level of protection drives glass selection.

There are three compliance options:

- Testing (either shock tube or open arena),
- Static calculations, or
- Dynamic calculations.

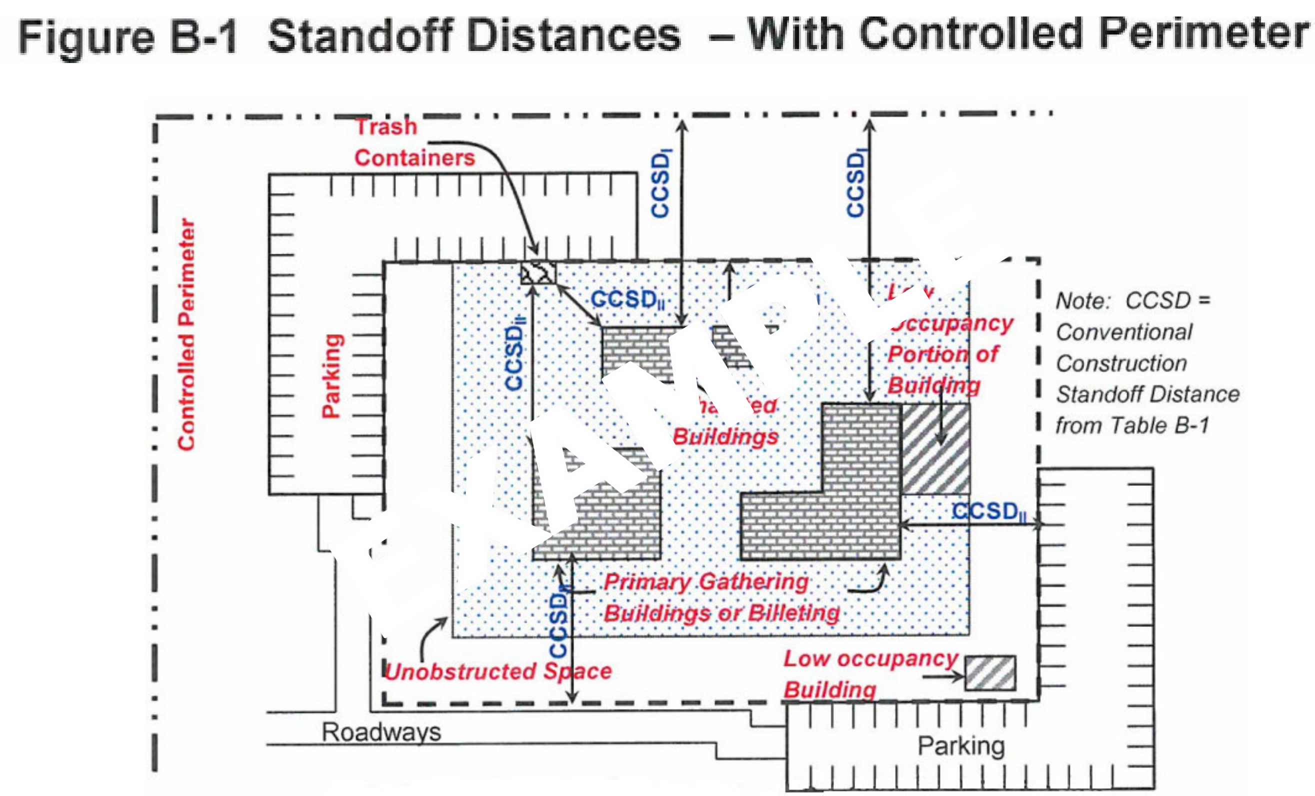
The latter offers the "best value" solution and is often required by project specifications.

Depending on orientation and site, the same building may be subject to multiple blast loads. Glazed walkways, exterior stairwells and vestibules may be "special cases."

In the most-recent UFC neither "conventional construction standoff distance" nor "low level blast" still apply to windows. Windows are now designed to address the actual threat.

Threat Assessment

A job for ATFP professionals, not window engineers



On-base controlled perimeters are generally considered as stopping car-size threats, but may not stop satchel-size charges

Blast Testing Options

Testing this configuration…

…does NOT qualify this configuration

Once commonplace, blast testing has generally been supplanted by dynamic calculation methodologies.

In general, a sample size of n=3 is required to validate performance of any product through blast testing.

Shock tube testing cost is moderate, but subject to defined limits on size variation, pressure, and configuration, often resulting in dozens of tests for a single building.

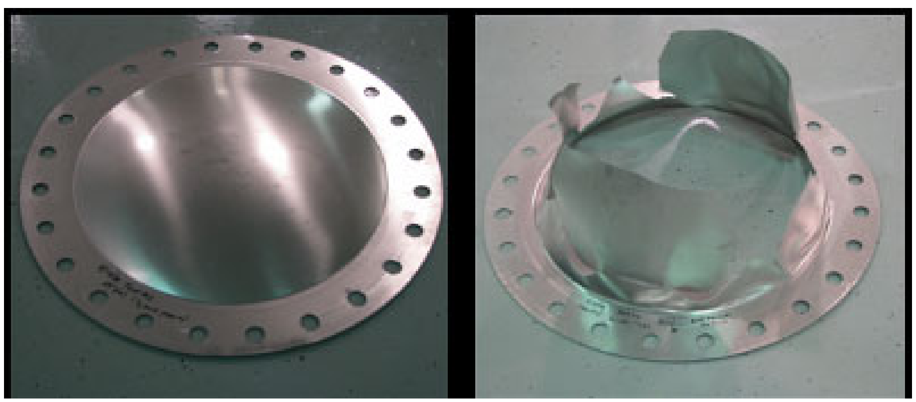
Open arena testing cost is higher, but allows for larger specimen sizes and concurrent testing of multiple configurations at higher pressures.

Any testing-based compliance verification may have limited applicability across projects, due to variation in size, configuration, anchorage, building substrates and blast loads.

Shock Tube Testing

on a window system

Shock Tube Test Apparatus



Aluminum Pressure Diaphragm

INvent™ window system
Intertek ATI, York, PA
Project In Casement / Fixed
6 psi * 42 psi.msec

Play video

Open Arena Testing

on a curtainwall system

INvision™ Curtainwall System
HTL Lubbock, Texas
10 psi * 89 psi.msec
129' standoff, 850 lbs ANFO

Play Video
(exterior)

Play Video
(interior)

Calculation Compliance Options

Calculation methodologies and tools such as WINGARD and SDOF have been developed by industry experts and validated through more than thirty years of testing experience.

Using conservative static equivalent calculation methodology, design blast loads are determined by the glass load resistance. Frames and anchors are designed to withstand double the glass load resistance. Structural silicone glazing is required.

Using accurate, "best value" dynamic calculation methodologies, design blast loads are determined using actual pressure and impulse from explosive weight and standoff at the location where the windows are sited.

Frames and anchors are designed to ultimate capacity, using actual design blast load(s), with glazing method per calculations. Dry glazing may be possible with adequate glass bite.

General Services Administration (GSA)

Interagency Security Committee (ISC) Standard

Clemente Ruiz Nazario U.S. Courthouse and Federico Degetau Federal Building San Juan, Puerto Rico

GSA buildings seldom have controlled perimeters, and are often occupied by civilians.

In a 2016 overview prepared by ARA Associates (available at the WBDG), applicability of the two standards was explained:

"The [ISC] was developed for federal civilian government agencies and the UFC… for DoD facilities…

[The ISC] is applicable to all buildings and facilities in the United States occupied by Federal employees for nonmilitary activities [as well as] off-installation leased space managed by DoD…

[The UFC] applies to the Military Departments, the Defense Agencies, and the DoD Field Activities.

[ISC] is more directed at physical and electronic security and operational countermeasures… While there is some limited guidance with respect to structural upgrades, these are general in nature…UFC 4-010-01 is focused on facility design to resist specific baseline threats. "

ISC's Federal Security Levels (FSLs)

Facility Security Level	Level of Risk	Baseline Level of Protection
I	Minimum	Minimum
II	Low	Low
III	Medium	Medium
IV	High	High
V	Very High	Very High

FSL I: No blast protection requirements

FSL II: Tempered glass, film, or catch systems

FSL III: Laminated glass or film on interior glass attached to frame

FSL IV: Threat assessment required, blast design per ISC criteria

FSL V: Threat assessment required, blast design per ISC criteria

The WBDG goes on to explain,

"The ISC Standard classifies facilities with a facility security level (FSL)… [that] depends upon five factors: mission criticality, symbolism, facility population, facility size, and threat."

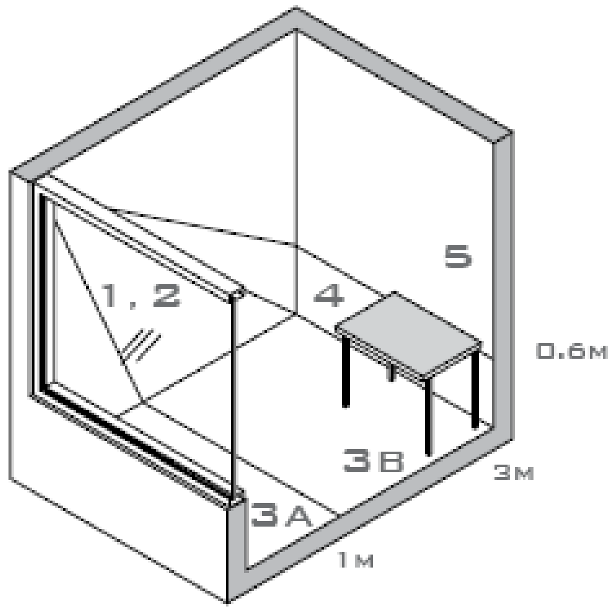
For FSL IV and FSL V security levels, detailed blast hazard mitigation design must be undertaken.

Early involvement by building envelope experts helps ensure proper system selection, clarifies design criteria and facilitates value engineering.

"Performance Condition" is the key GSA design criteria.

GSA Performance Condition

defines level of protection and window glazing response to limit hazard to occupants



Performance Condition	Protection Level	Hazard Level	Description of Window Glazing Response
1	Safe	None	No glazing breakage or visible damage.
2	Very High	None	Glazing cracks. Dusting of fragments.
3a	High	Very Low	Glazing cracks. Fragments on floor within 1m of window.
3b	High	Low	Glazing cracks. Fragments on floor within 3m of window.
4	Medium	Medium	Glazing cracks. Fragments impact lower 0.6m of wall.
5	Low	High	System fails catastrophically.

Typical GSA Requirements

Some highlights

"Balanced design" or "glass fails first" may be specified for certain critical facilities

For proper energy absorption, the glass must remain in the frame long enough to "fail," i.e. develop its full strength

What effect does balanced design have on fenestration system design?

The capacity of the frame must exceed the capacity of the glass, and the capacity of the anchors must exceed the capacity of the frame.

Specified blast performance parameters are only a starting point for determining the actual load requirements

Minimum glass make-up required for blast resistance may not consider aesthetics, fabrication limits, or heat treatment requirements for coatings, shading or safety glazing areas, requiring that stronger glass be employed.

With the use of stronger glass, a typical 4 psi–28 psi.msec specification may require an 8 psi–39 psi.msec framing design.

Variables include glass size(s), actual glass make-ups, configurations, or ballistic resistance mandates

Section Three

Hurricane Windows

Hurricane Basics

Better-than-code performance has been specified more often since Hurricane Sandy hit the Northeast with devastating effect in 2012.

FM Global estimates that every $1 spent on hurricane protection reduces loss exposure by an average of $105.

Hurricane intensity is measured on the Saffir-Simpson Hurricane Wind Scale – Categories 1 through 5.

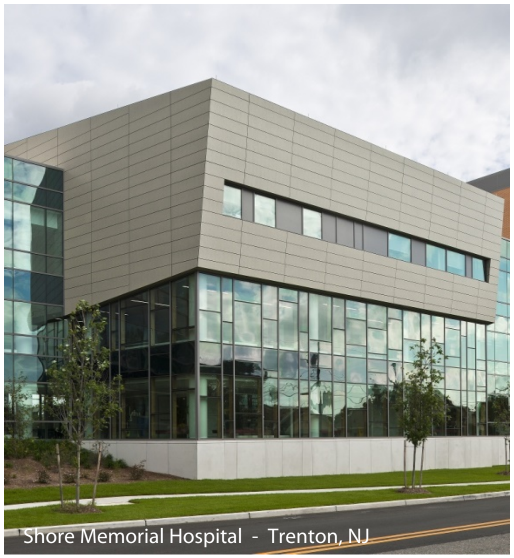
Katrina was a Category 1 storm when making landfall in Florida in 2005 with 74 to 95 mph sustained winds, while in 1992, Andrew made landfall as a Category 5 storm, with sustained winds exceeding 157 mph.

The building envelope is the primary line of defense against wind-borne debris in a hurricane or other severe weather event.

Windows are weak points susceptible to failure by wind pressure and blowing debris.

Once building envelope failure occurs, wind pressure builds up inside the building, potentially resulting in the roof lifting off the building and the walls collapsing.

Codes and Standards



Codes and standards address both wind pressure and wind-borne debris - separate but related criteria

It's always a good idea to get a PE involved in design for hurricane impact resistance

Model Building Codes such as the International Building Code (IBC) form the basis for adoption by authorities having jurisdiction (AHJ).

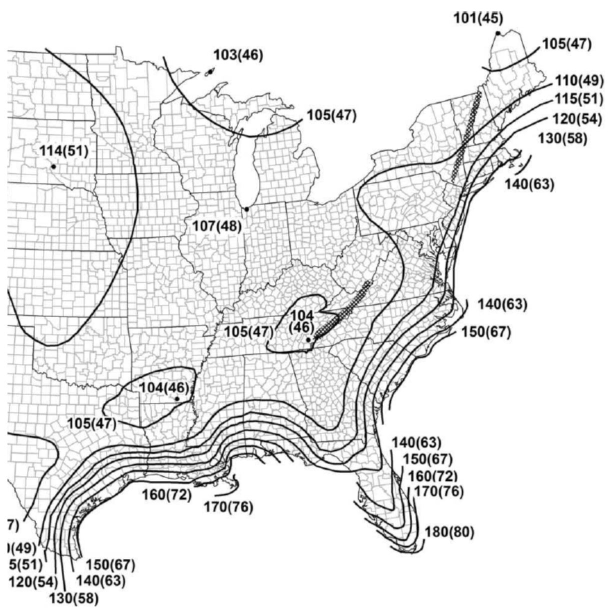
Some AHJ's regulations, including the Florida Building Code (FBC) and the Hawaii State Building Code, include a significant number of local amendments.

Standards and test methods applicable to hurricane impact protection referenced by codes include ASCE 7, ASTM E1996 and E1886, Miami-Dade TAS 201, 202, and 203, as well as AAMA 506 and 520.

The Florida DBPR, Miami-Dade Product Control and the Texas Department of Insurance (TDI) administer approval, certification and/or labeling programs to ensure compliance of building products - including windows, doors and curtainwall.

Wind-Borne Debris Protection

Step-by-Step



There are separate ultimate wind speed (V_{ult}) maps in ASCE 7-10 and ASCE 7-16 for Risk Category II buildings versus Risk Category III/IV buildings

STEP ONE – Wind Design Criteria

Determine the authority having jurisdiction (AHJ), and any mandatory labeling or certification requirements.

Building occupancy and use drive requirements. RC III structures pose substantial hazard to human life and RC IV structures are essential facilities. Other buildings are RC II.

Use the correct map from ASCE7 or http://hazards.atcouncil.org to determine ultimate wind speed at the building site.

Calculate design wind pressure using the Enseweiler formula with factors for exposure, building height, gusts, full enclosure, components and cladding, tributary area, etc. Keep Allowable Stress Design (ASD) and Strength Design wind loads sorted out and clearly identified.

Basic structural design information is often presented on Sheet S-001.

Wind-Borne Debris Protection

Step-by-Step (Continued)

STEP TWO - Wind Zone

Considering wind speed at the site and proximity to the coastline, determine the appropriate Wind Zone.

IBC 2018 WIND ZONES (ASCE 7-16 wind speeds)	
WIND ZONE 1	130 mph ≤ ultimate design wind speed < 140 mph
WIND ZONE 2	140 mph ≤ ultimate design wind speed < 150 mph at greater than 1 mile from coastline[1]
WIND ZONE 3	150 mph ≤ultimate design wind speed ≤ 160 mph* ---OR---- 140 mph ≤ultimate design wind speed ≤ 160 mph* and within 1 mile from coastline[1]
WIND ZONE 4	ultimate design wind speed > 160 mph*
[1] coastline measured form the mean high water mark	

*NOTE: The Florida Building Code Wind Zone 3 and 4 threshold is 170 mph rather than 160 mph

STEP THREE – Missile Type

For the site's Wind Zone, determine Missile Type required given the building Risk Category and the product's height above grade.

Small "A" missile: 2g steel ball
Large "C, D and E" missiles: 4.5 to 9 lb. stud
Missile speeds: 40 to 130 fps

FEMA tornado missiles may be required for ICC 500 storm shelter design.

Wind Zone	Missile Type			
	Enhanced Protection (Essential Facilities)		Basic Protection	
	30 feet and below	Above 30 feet	30 feet and below	Above 30 feet
Wind Zone 1	D	D	C	A
Wind Zone 2	D	D	C	A
Wind Zone 3	E	D	D	A
Wind Zone 4	E	D	D	A

Wind-Borne Debris Protection

Step-by-Step (Continued)

Play video

AHJ labeling and certification requirements can affect the specifics of the test regimen, as can the site's Wind Zone - whether standard product certification or project-specific qualification.

STEP FOUR – Testing Specifications

Products undergo pre-qualification testing for air infiltration, water penetration resistance and uniform static structural loading.

For impact testing, small or large missiles are fired from an air cannon to hit various impact locations on the glass, and in Wind Zone 4, frame locations as well.

Missile impacts are followed by pressure cycling - 9000 cycles from 20% of ASD design pressure up to full ASD pressure; positive and negative.

After cycling, there shall be no penetrations large enough to allow pressurization of interior spaces.

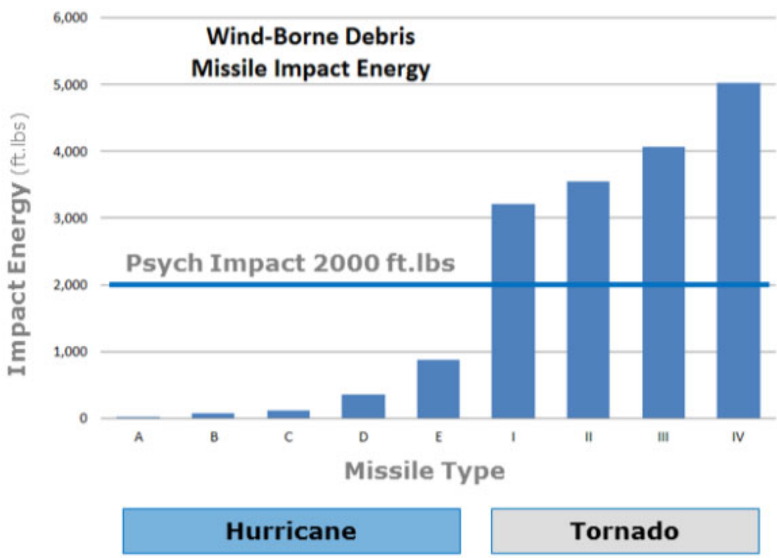
Successful test reports are submitted to PEs, validators, AHJs and/or administrative agencies for approval, a process that can be quite time-consuming.

Section Four

Protective Glazing Summary

Protective Window Design

In Context



Behavioral care, blast hazard mitigation and hurricane impact share a common vernacular – that of energy absorption.

Know your AHJ's permitting requirements as well as the building owner's expectations.

To avoid delays and change orders, make sure project specifications are responsive and technically valid. Manufacturers can help.

Don't leave basic design criteria such as Risk Category, level of protection, design wind speed, exposure and Wind Zone open for interpretation by bidders. Be explicit.

In product comparison and selection, check for existing product certifications, as product breadth and customization may be limited. Project-specific testing has schedule and cost impacts, even if initially successful.

Protective Window Design

In Context

FEMA provides a tornado wind zone map for risk assessment.

(Not to be confused with IBC hurricane Wind Zones)

The Enhanced Fujita (EF) scale is used to rate tornadoes.

What's next in protective window and door design?

Tornado shelter requirements from ICC 500 are being included in Model Building Codes for certain school and municipal buildings that serve as places of refuge.

While the worst EF4 and EF5 tornados defy conventional design solutions, EF1 and EF2 tornados are often "embedded" in hurricanes, and can be addressed using commercially available products and known impact/cycling test protocols.

Code requirements for water penetration resistance in extreme weather events have been proposed by a number of stakeholders.

A general focus on resiliency has been adopted as a sustainable design initiative, to include flood water resistance.

A Final Word

Design Criteria

"Balanced design" is key. Selection should be based on <u>all</u> applicable criteria, not on any single number rating system.

Almost all projects share a list of design criteria for fenestration:

Code Compliance
Structural Integrity
Weather-ability
Energy Efficiency
Condensation Resistance
Ventilation and Cleaning Access
Sustainable Design
Durability
Cost
Aesthetics

…and on some projects, also:

Emergency Egress
Hurricane Impact
Behavioral Care
Detention
Blast Hazard Mitigation
Noise Control
Seismic Movements
Smoke Evacuation

PROTECTIVE WINDOW DESIGN
Behavioral Care, Blast and Hurricane

Learning Objectives

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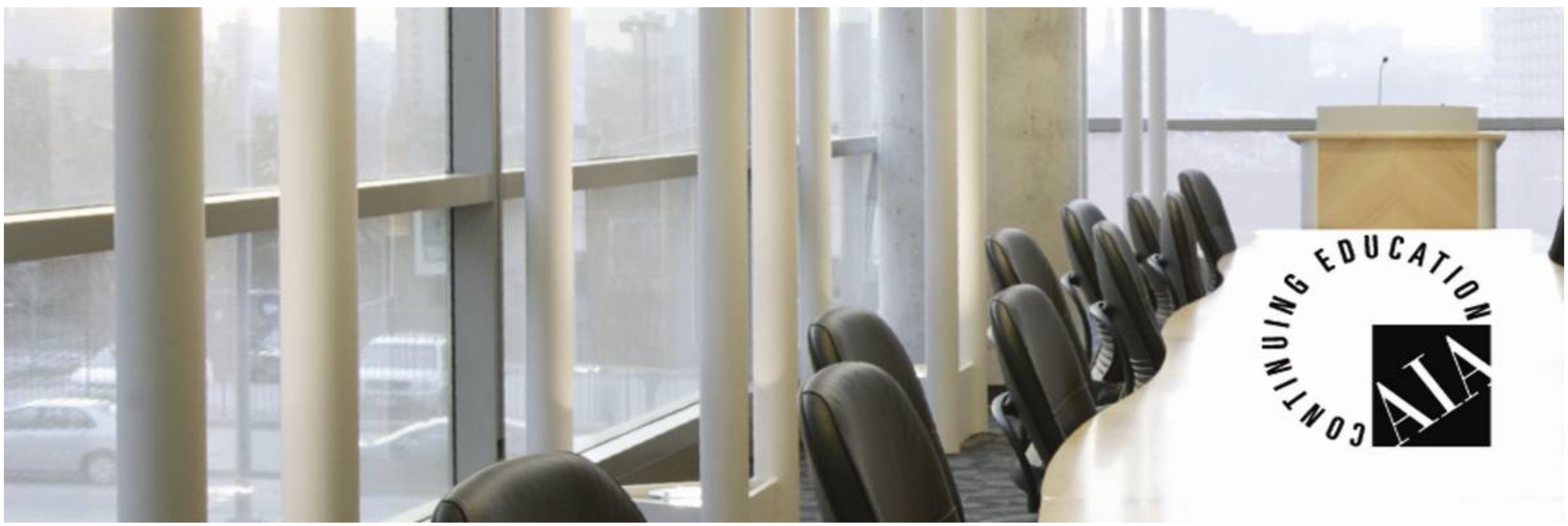

Course Evaluations

In order to maintain high-quality learning experiences, please access the evaluation for this course by logging into CES Discovery and clicking on the Course Evaluation link on the left side of the page.

LA Police Department Headquarters

WAUSAU WINDOW AND WALL SYSTEMS

Click here to take Test