EXPERIENCE . DESIGN and ANALYSIS . PRODUCTS . TESTING . WARRANTY

WAUSAU

WINDOW AND WALL SYSTEMS

BLAST HAZARD MITIGATION

FOR WINDOWS AND CURTAINWALL

As windows and curtainwall encounter the extreme pressure released by an explosive mass, all elements of the assembly work together. Modern, blast-mitigating assemblies are intended to be flexible and absorb blast energy, creating elegant, quiet, daylight-filled, environmentally-responsible, and safe buildings.

U.S. GREEN BUILDING COUNCIL MEMBER

EXPERIENCE in DESIGN and ANALYSIS

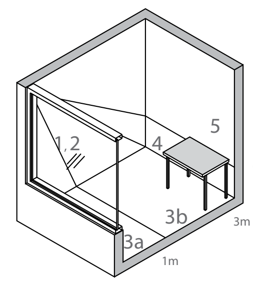
With years of experience on dozens of major blast projects nationwide, Wausau can interpret the lexicon of blast hazard mitigation, and design for safety and cost-effectiveness. Blast hardened re-cladding of an existing building, hazard-mitigating replacement windows, or a modern all-glass facade for a new building, Wausau has the technical expertise to interface with the design team from inception to timely completion.

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, however, there is no "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. Depending on orientation and site, the same building may be subject to multiple blast loads.

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.

IMPORTANT NOTE: Determination of peak pressure, impulse, and Performance Condition (to include Hazard Condition and Protection Level) is the responsibility of the Owner's security/blast consultant; not the window/curtainwall manufacturer or installer. Design parameters typically range from 4 psi peak and 28 psi-msec impulse, to 10 psi peak and 89 psi-msec impulse.



DoD - UFC

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

Airblast peak loads and impulse for windows are now determined from a "Design Threat Analysis," which considers, Charge Weight (I and/or II), as well as Standoff distance. Level of protection drives glass selection. There are three compliance options, a) testing (either shock tube or open arena), b) static calculations, or c) dynamic calculations. The latter offers the "best value" solution and is often required by project specifications.

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

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.

GSA - ISC

General Services Administration (GSA)
Interagency Security Committee (ISC) Standard

GSA buildings seldom have controlled perimeters, and are often occupied by civilians. As the WBDG explains, "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 as shown in the Table above.


Zorinsky Federal Building , Omaha, NE , Leo A. Daly Architects

PRODUCTS

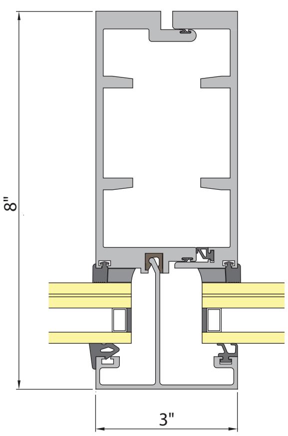
BHM WINDOWS AND CURTAINWALL

What effect does balanced design have on fenestration system design? The structural design of the frame must consider the loads imparted by the glass, and the design of the anchors must consider the loads imparted by the frame. Specified blast performance parameters are only a starting point for determining the actual load requirements. “Balanced design” or “glass fails first” design protocols may be specified for certain critical facilities.

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

INvision™ 8000i-BHM

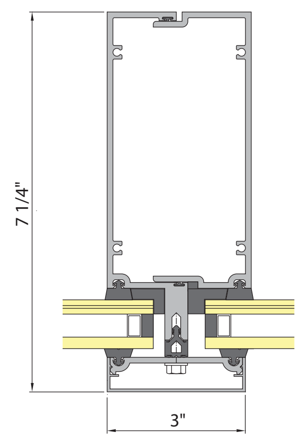
Unitized Window Wall and Curtainwall



- Open arena-tested
- Interlocking frame design accommodates seismic, live load and thermal movements
- Thermally improved; polyamide thermal barrier optional
- Structural silicone glazing and sealing in a controlled factory environment
- Exterior sun shades and interior light shelves

SuperWall™-BHM

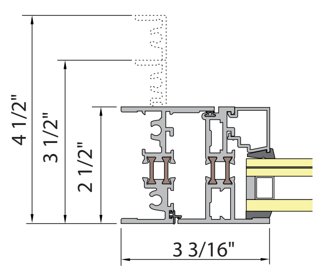
Field-Glazed Window Wall and Curtainwall



- Several frame depths including cladding for steel tubes
- 3" exterior sight line
- Captured or two-side structural silicone glazed in the field
- Screw-spline construction
- Exterior sun shades and interior light shelves

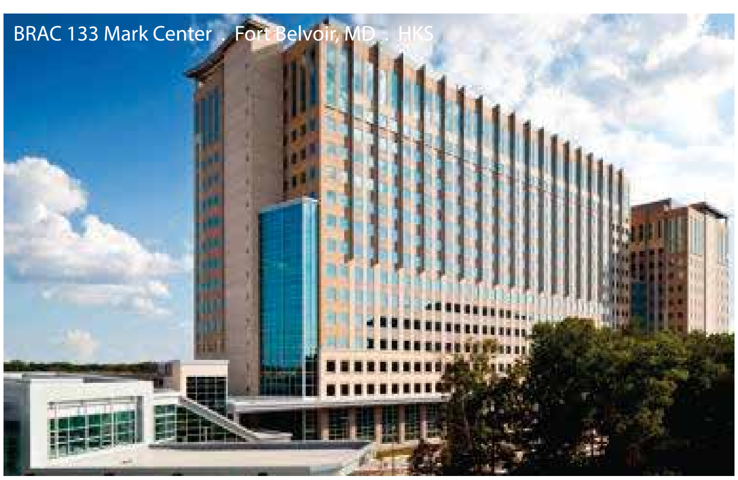
INvent™ 2250i-, 3250i- and 4250i-BHM

Fixed and Operable Windows



2250i-BHM
6 psi-42 psi-msec

- 2-1/2", 3-1/2" and 4-1/2" frame depth with polyamide thermal barrier - Two color option
- Fixed, awning, or project-out casement - **Project-in** hopper and casement available for some configurations
- Various 2250i- and 3250i-BHM configurations achieve ASTM F1642 “Minimal Hazard” or “No Hazard” rating, shock tube-tested at 6 psi peak, 42 psi-msec impulse
- Various 4250i-BHM configurations achieve ISC Performance Conditions 1, 2, 3a or 3b, shock tube-tested at 10 psi peak, 89 psi-msec impulse

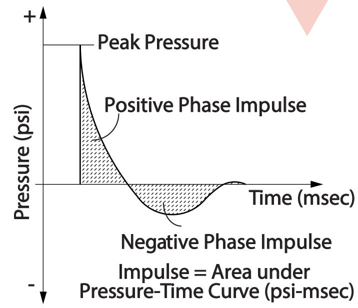


BRAC 133 Mark Center . Fort Belvoir, MD . HKS

ANG Shepperd Hall . Joint Base Andrews . AECOM (DMJM)

TESTING

Blast load is usually quantified as an inter-related combination of peak pressure (psi) and impulse (psi.msec) Peak Pressure represents the maximum overpressure of the initial air shock wave measured in pounds per square inch (psi). Duration is the time required for the initial pressure to return to zero (msec). Impulse is defined as the area under the pressure-time curve, i.e., 0.5 times duration times peak pressure. Requirements can range from 4 psi-28 psi.msec to 10 psi-89 psi.msec or higher.



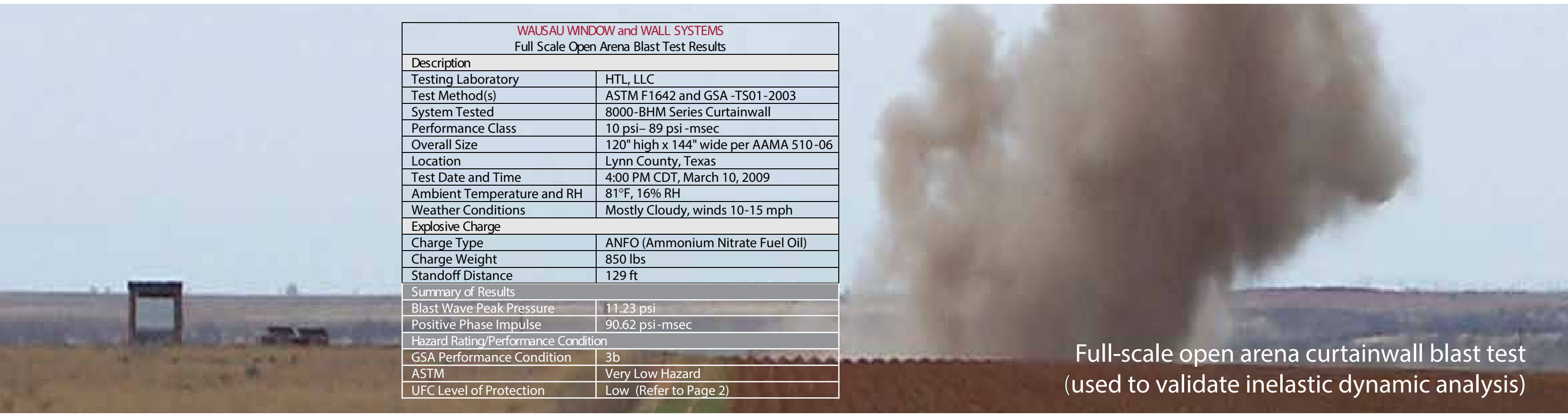
In general, a sample size of three is required to validate performance of any product through blast testing. Shock tube testing cost is moderate, but subject to defined limits on size variation, pressure, and configuration, often resulting in dozens of tests for a single building. Open arena testing 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. Once commonplace, blast testing has generally been supplanted by validated dynamic calculation methodologies.

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

Photo courtesy of ATI Intertek

Indoor shock tube window blast test
(used to validate inelastic dynamic analysis)



WAUSAU WINDOW and WALL SYSTEMS Full Scale Open Arena Blast Test Results	
Description	
Testing Laboratory	HTL, LLC
Test Method(s)	ASTM F1642 and GSA -TS01-2003
System Tested	8000-BHM Series Curtainwall
Performance Class	10 psi– 89 psi -msec
Overall Size	120" high x 144" wide per AAMA 510-06
Location	Lynn County, Texas
Test Date and Time	4:00 PM CDT, March 10, 2009
Ambient Temperature and RH	81°F, 16% RH
Weather Conditions	Mostly Cloudy, winds 10-15 mph
Explosive Charge	
Charge Type	ANFO (Ammonium Nitrate Fuel Oil)
Charge Weight	850 lbs
Standoff Distance	129 ft
Summary of Results	
Blast Wave Peak Pressure	11.23 psi
Positive Phase Impulse	90.62 psi-msec
Hazard Rating/Performance Condition	
GSA Performance Condition	3b
ASTM	Very Low Hazard
UFC Level of Protection	Low (Refer to Page 2)

Full-scale open arena curtainwall blast test
(used to validate inelastic dynamic analysis)

WAUSAU
WINDOW AND WALL
SYSTEMS

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