Preparing Activity: NAVFAC Superseding
UFGS-08 56 53 (August 2011)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023
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SECTION 08 56 53

BLAST RESISTANT TEMPERED GLASS WINDOWS

08/20

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USACE / NAVFAC / AFCEC / NASA	**UFGS-08 56 53 (August 2020)**

Preparing Activity: NAVFAC	**Superseding**
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UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023
****

SECTION 08 56 53

BLAST RESISTANT TEMPERED GLASS WINDOWS
08/20

****
NOTE: This guide specification covers the requirements for blast resistant tempered glass windows that require upgrades based on the blast, antiterrorism, and setback requirements set forth in UFC 4-010-01, DoD Minimum Antiterrorism Requirements for Buildings.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).
****

****
NOTE: Specific details are expanded upon in MIL-HBK-1013/1A, Design Guidelines for Physical Security of Facilities.
****

****
NOTE: To download UFGS Forms, Graphics, and Tables, go to: http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphics-tables
****

****
NOTE: On the drawings, show:

1. Locations of each type of glass, using same terminology as in the specification.

2. Frame and rabbet details, indicating method of glazing.

3. Sizes and types of windows; metal and wood subframes, casings, or stools, if any; and hardware.

4. Sizes, location, and swing of ventilators; direction of slide for sliding ventilators; location and details of fixed sash.

5. Typical window sections and details. Show glass thickness. Show special glazing, if any.

6. Method of anchoring windows; size and types of clips, anchors, screws, or other fasteners.

7. Details of nonstructural mullions and mullion covers; detail of anchoring and reinforcing nonstructural mullions at windows to receive window cleaner anchors.

8. Number of window cleaner anchors required and locations.

9. Locations of windows designated as forced entry resistant, if any.

****

PART 1 GENERAL

1.1 REFERENCES

****

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

****

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by

the basic designation only.

ALUMINUM ASSOCIATION (AA)

AA DAF45	(2003; Reaffirmed 2009) Designation System for Aluminum Finishes

AMERICAN ARCHITECTURAL MANUFACTURERS ASSOCIATION (AAMA)

AAMA 611	(2014) Voluntary Specification for Anodized Architectural Aluminum
AAMA 2603	(2020) Voluntary Specification, Performance Requirements and Test Procedures for Pigmented Organic Coatings on Aluminum Extrusions and Panels
AAMA 2605	(2020) Voluntary Specification, Performance Requirements and Test Procedures for Superior Performing Organic Coatings on Aluminum Extrusions and Panels
AAMA WSG.1	(1995) Window Selection Guide
AAMA/WDMA/CSA 101/I.S.2/A440	(2017) North American Fenestration Standard/Specification for Windows, Doors, and Skylights

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z97.1	(2015) Safety Glazing Materials Used in Buildings - Safety Performance Specifications and Methods of Test

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 169	(2013) Climate Data for Building Design Standards

ASTM INTERNATIONAL (ASTM)

ASTM C509	(2006; R 2021) Standard Specification for Elastomeric Cellular Preformed Gasket and Sealing Material
ASTM C920	(2018) Standard Specification for Elastomeric Joint Sealants
ASTM C1048	(2018) Standard Specification for Heat-Strengthened and Fully Tempered Flat Glass
ASTM E1300	(2016) Standard Practice for Determining Load Resistance of Glass in Buildings
ASTM E1886	(2019) Standard Test Method for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective

	Systems Impacted by Missile(s) and Exposed to Cyclic Pressure Differentials
ASTM E1996	(2017) Standard Specification for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Windborne Debris in Hurricanes
ASTM F1642/F1642M	(2017) Standard Test Method for Glazing and Glazing Systems Subject to Airblast Loadings
ASTM F2248	(2012) Standard Practice for Specifying an Equivalent 3-Second Duration Design Loading for Blast Resistant Glazing Fabricated with Laminated Glass
ASTM F2912	(2017) Standard Specification for Glazing and Glazing Systems Subject to Airblast Loadings

GLASS ASSOCIATION OF NORTH AMERICA (GANA)

GANA Glazing Manual	(2008) Glazing Manual

NATIONAL FENESTRATION RATING COUNCIL (NFRC)

NFRC 100	(2020) Procedure for Determining Fenestration Product U-Factors
NFRC 200	(2020) Procedure for Determining Fenestration Product Solar Heat Gain Coefficient and Visible Transmittance at Normal Incidence

PASSIVE HOUSE INSTITUTE - US (PHIUS)

PHIUS Certified	Certified Data Program for Window Performance

PASSIVE HOUSE INSTITUTE INTERNATIONAL (PHI)

Passivhaus Certified	(2012) Certification of Passive House Suitable Components
Passivhaus Criteria	(2012) Certification Criteria for Certified Passive House Glazings and Transparent Components

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 4-010-01	(2018; with Change 2, 2022) DoD Minimum Antiterrorism Standards for Buildings

U.S. DEPARTMENT OF ENERGY (DOE)

Energy Star	(1992; R 2006) Energy Star Energy Efficiency Labeling System (FEMP)

1.2 SUBMITTALS

****

NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

Choose the first bracketed item for Navy, Air Force, and NASA projects, or choose the second bracketed item for Army projects.

****

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Windows; G[, [_____]]

Fabrication Drawings

SD-03 Product Data

Window Units; G[, [_____]]

Hardware

Setting Materials

Weatherstripping

SD-04 Samples

Finish Sample

Window Sample

[Window Mock-Ups; G[, [_____]]

] SD-05 Design Data

Structural Calculations for Deflection; G[, [_____]]

Design Analysis; G[, [_____]]

SD-06 Test Reports

Minimum Condensation Resistance Factor

[Resistance to Forced Entry

][Standard Airblast Test; G[, [_____]]

][Windborne-Debris-Impact Performance

] SD-07 Certificates

****

NOTE: Provide engineer's qualifications when required to show conformance to UFC 4-010-01, DoD Minimum Antiterrorism Requirements for Buildings.

****

[Engineer's Qualifications

] SD-08 Manufacturer's Instructions

Glass

SD-10 Operation and Maintenance Data

Window Units, Data Package 1; G[, [_____]]

1.3 QUALITY ASSURANCE

1.3.1 Qualification of Manufacturer

Window manufacturer must specialize in designing and manufacturing the type of aluminum windows specified in this section, and have a minimum of [_____] years of documented successful experience. Manufacturer must have the facilities capable of meeting contract requirements, single-source responsibility and warranty.

1.3.2 Shop Drawing Requirements

Take field measurements prior to preparation of drawings and fabrications. Provide drawings that indicate elevations of windows, full-size sections, thickness and gages of metal, fastenings, proposed method of anchoring, size and spacing of anchors, details of construction, method of glazing, details of operating hardware, [mullion details,] [method and materials for weatherstripping,] [method of attaching screens,] [material and method of attaching subframes,] [stools,] [casings,] [sills,] [trim,] [window cleaner anchors,] installation details, and other related items.

[1.3.3 Engineer's Qualifications for Blast Design

****

NOTE: Provide engineer's qualifications when required to show conformance to UFC 4-010-01, DoD Minimum Antiterrorism Requirements for Buildings.

****

All blast design calculations must be performed by or under the direct supervision of a registered engineer with a minimum of 5 years experience performing blast design. The engineer performing the blast design must be able to demonstrate experience on similar size projects using similar design methods to meet the requirements outlined in this specification.

]1.3.4 Sample Requirements

1.3.4.1 Finish Sample Requirements

Submit color chart of standard factory color coatings when factory-finish color coating is to be provided.

1.3.4.2 Window Sample Requirements

****

NOTE: Choose one of the following options. Include the first choice for projects requiring a large number of windows. Include the second choice for projects requiring a limited number of windows.

****

[Submit one full-size window of each type proposed for use, complete with AAMA Label, glazing, hardware, anchors, and other accessories. Where screens or weatherstripping is required, fit sample windows with such items that are to be used. After approval, install each sample in work, clearly identified, and record its location.

][Submit one full-size corner of each window type proposed for use. Where screens or weatherstripping is required, fit sample with such items that are to be used.

][1.3.4.3 Window Mock-Ups

****

NOTE: Requesting mock-up samples of aluminum windows is not required for most projects. Size of project and scope of quality control should be carefully evaluated before requiring Contractor to

provide a costly mock-up. Delete paragraph if mock-ups are not required.
****

Before fabrication, full-size mock-up of [each type of aluminum window] [one window unit] [_____] complete with glass and AAMA certification label for structural purposes and NFRC Temporary and Permanent Label for certification of thermal performance rating will be required for review of window construction and quality of hardware operation.

]1.3.5 Design Data Requirements

Submit structural calculations for deflection to substantiate compliance with requirements[and Antiterrorism Performance Requirements]. A registered Professional Engineer must provide calculations. Submit design analysis with calculations showing that the design of each different size and type of aluminum window unit and its anchorage to the structure[.] [meets the requirements of paragraph ANTITERRORISM PERFORMANCE REQUIREMENTS.] Calculations verifying the structural performance of each window proposed for use, under the given loads, must be prepared and signed by a registered professional engineer. Reflect the window components and anchorage devices to the structure, as determined by the design analysis, in the shop drawings.

1.3.6 Test Report Requirements

****
NOTE: Include bracketed wording when windows are required to resist blast loads all required by UFC 4-010-01, DoD Minimum Antiterrorism Requirements for Buildings.
****

Submit test reports for each type of window attesting that identical windows have been tested and meet the requirements specified herein for conformance to AAMA/WDMA/CSA 101/I.S.2/A440 including test size, [and] minimum condensation resistance factor (CRF)[, and resistance to forced entry][, and, for Antiterrorism windows, in lieu of a Design Analysis, results of a Standard Airblast Test].[For Antiterrorism windows, in lieu of a Design Analysis, results of airblast testing, whether by arena test or shock tube, must be included in a test report, providing information in accordance with ASTM F1642/F1642M, as prepared by the independent testing agency performing the test. The test results must demonstrate the ability of each window proposed for use to withstand the airblast loading parameters and achieve the hazard level rating specified in paragraph STANDARD AIRBLAST TEST METHOD.]

1.3.7 Certification

****
NOTE: Energy Star Certification is required for residential windows. FEMP Designation, Passivhaus, and PHIUS Certifications are methods to ensure compliance with thermal performance.
****

Ensure that construction is performed with products that meet or exceed [Energy Star criteria,] [FEMP Designated criteria,] [and Passivhaus Criteria] [Passivhaus Certified] [and be current in their certification].[

Provide PHIUS Certified window performance.] Each prime window unit must bear the AAMA Label warranting that the product complies with AAMA/WDMA/CSA 101/I.S.2/A440. Certified test reports attesting that the prime window units meet the requirements of AAMA/WDMA/CSA 101/I.S.2/A440, including test size, will be acceptable in lieu of product labeling.

1.3.8 Label

Each prime window unit must bear the AAMA Label warranting that the product complies with AAMA/WDMA/CSA 101/I.S.2/A440. Certificates of Compliance attesting that the prime window units meet the requirements of AAMA/WDMA/CSA 101/I.S.2/A440 will be acceptable in lieu of product labeling.

1.3.9 Glass and Glazing

Provide materials that are certified to meet ANSI Z97.1 by an independent testing laboratory.

1.4 DELIVERY, STORAGE, AND HANDLING

a. Deliver products to the site in unopened containers, labeled plainly with manufacturers' name and brands. Deliver window assemblies in an undamaged condition. Exercise care in handling and hoisting windows during transportation and at the job site. Store windows and components out of contact with the ground, under a weathertight covering, so as to prevent bending, warping, or otherwise damaging the windows.

b. Finished surfaces must be protected during shipping and handling using the manufacturer's standard method, except that no coatings or lacquers shall be applied to surfaces to which sealants, caulking, or glazing compounds must adhere.

1.5 ENVIRONMENTAL CONDITIONS

Do not start glazing work until the outdoor temperature is above 4 degrees C 40 degrees F and rising unless approved provisions are made to warm the glass and rabbet surfaces. Provide sufficient ventilation to prevent condensation of moisture on glazing work during installation. Do not perform glazing work if moisture collects on window assemblies or during rainy weather.

1.6 PERFORMANCE REQUIREMENTS

1.6.1 Wind Loading Design Pressure

Design window components, including mullions, hardware, and anchors, to withstand a wind-loading design pressure of at least [_____] pascal pounds per square foot (psf).

[1.6.2 Tests

Test windows proposed for use in accordance with AAMA/WDMA/CSA 101/I.S.2/A440 for the particular type and quality window specified.

Perform tests by a nationally recognized independent testing laboratory equipped and capable of performing the required tests. Submit the results

of the tests as certified laboratory reports required herein.

Minimum design load for a uniform-load structural test must be 2400 pascal 50 psf.

[Test projected windows in accordance with the applicable portions of the AAMA WSG.1 for air infiltration, water resistance, uniform-load deflection, and uniform-load structural test.

][Test double-hung windows in accordance with the applicable portions of the AAMA WSG.1 for air infiltration, water resistance, uniform-load deflection, and uniform-load structural test.

]]1.7 DRAWINGS

Submit the fabrication drawings for aluminum window units showing complete window assembly including hardware, weatherstripping, and subframe assembly details.

1.8 WINDOW PERFORMANCE

****

NOTE: Structural performance, air infiltration and water penetration are standard performance requirements for all aluminum window types.

Design must meet the requirements of UFC 1-200-02, "High Performance and Sustainable Building Requirements" which invokes the requirements within UFC 3-101-01, "Architecture". UFC 1-200-02 and UFC 3-101-01 make references throughout to various ASHRAE documents governing energy efficiency and requirements for the components of building envelope design including fenestrations and glazing.

ANTITERRORISM PERFORMANCE REQUIREMENTS section below is optional to designer, and must be omitted or revised as needed to meet project requirements.

Applicability of UFC 4-010-01 DoD Minimum Antiterrorism Standards for Buildings.

The antiterrorism (AT) standards contained in UFC 4-010-01 DO NOT establish the Design Basis Threat (DBT) or the Level of Protection (LOP) for DoD buildings. Installation Antiterrorism Plans may define a DBT for the installation. Use UFC 4-020-01 (DoD Security Engineering Facilities Planning Manual) to establish and/or validate the DBT and LOP for individual projects. The process outlined in UFC 4-020-01 will determine if the minimum AT standards are adequate or if additional protective measures are required. Where a specific DBT and LOP are identified, additional guidance is included in Appendix B (Best Practices) of UFC 04-010-01. For buildings that are outside an installation perimeter, use UFC 4-020-01 to establish the DBT and LOP. The DBT and LOP will result in a representative standoff distance for the appropriate

construction - window systems (glazing, frame, connections) in this instance.

A structural analysis will need to be performed to determine if the most stringent loading on window assembly is from antiterrorism blast loads or windborne debris in high wind regions.

****

Aluminum windows must meet the following performance requirements. Perform testing requirements by an independent testing laboratory or agency.

1.8.1 Structural Performance

Structural test pressures on window units must be for positive load (inward) and negative load (outward). After testing, there will be no glass breakage, permanent damage to fasteners, hardware parts, support arms or actuating mechanisms or any other damage which could cause window to be inoperable. There must be no permanent deformation of any main frame, sash or ventilator member in excess of the requirements established by AAMA/WDMA/CSA 101/I.S.2/A440 for the window types and classification specified in this section.

[1.8.2 Antiterrorism Performance Requirements

Windows must meet the antiterrorism performance criteria as specified in the paragraphs below in accordance with UFC 4-010-01. Conformance to the performance requirements must be validated by one of the following methods.

1.8.2.1 Computational Design Analysis Method

Design window assembly to the criteria listed herein. Include computational design analysis calculations verifying the structural performance of each window assembly proposed for use, under the given static equivalent loads.

Design window frames, mullions, sashes, and glazing to the criteria listed herein. Include computational design analysis calculations verifying the structural performance of each window system proposed for use, under the given static equivalent loads.

****

NOTE: The blanks in the following paragraph should be the value of the equivalent 3-second duration design loading obtained from Figure 1 of ASTM F2248 for the explosive weight and standoff distance combination (based on the established DBT/LOP) that is being designed for in this project. This section must be completed by an engineer experienced in blast-resistant design.

****

Glazing resistance must be greater than equivalent 3-second duration loading of [_____] Pascal pounds per square foot (psf) for type [_____] window[and [_____] Pascal psf for the remaining window types]. The glazing frame bite for the window frames must be in accordance with ASTM F2248.

Design Aluminum/Steel window framing members to restrict deflections of the edges of glazing they support to L/60 under two times (2X) the glazing resistance per the requirements of ASTM F2248 and ASTM E1300.

****

NOTE: Connection Design: For mullion and framing members designed using dynamic analysis or shown to work through airblast testing, all connections between mullions and/or framing members and all connections of storefront systems to the supporting structure must be designed for the full dynamic capacity of the attached member or the maximum calculated dynamic reaction with a load factor equal to 1.0. Use ultimate capacity of fasteners as recommended by the fastener manufacturer with a capacity reduction factor of 0.75. Use Load and Resistance Factor Design (LRFD) with appropriate reduction (phi) factors per material specific code for design of connections components into supporting structure. All dynamic and static material strength increase factors for the connection components must be equal to 1.0. All connection designs must be performed checking all conventional failure mechanisms. See Engineering Technical Report (PDC TR-10-02) titled Blast Resistant Design Methodology for Window Systems Designed Statically and Dynamically at USACE Protective Design Center (Website link: pdc.usace.army.mil/library/tr/10-02) for additional information. Calculations/Design Analysis for the connection design as stated above must be completed by an engineer experienced in blast-resistant design.

****

****

NOTE: Use the first bracketed requirement below if the maximum air blast pressure is greater than one-half the magnitude of the load resistance of the blast resistant glazing.

Use the second bracketed requirement below if the maximum air blast pressure is less than one-half the magnitude of the load resistance of the blast resistant glazing.

****

[Anchor window frames to the supporting structure with anchors designed to resist [two times (2X)][one time (1X)] the glazing resistance in accordance with ASTM F2248 and ASTM E1300.

]1.8.2.2 Dynamic Design Analysis Method

****

NOTE: The blanks in the following paragraph should be the value of the peak positive pressure and impulse for the explosive weight and standoff distance combination (based on the established DBT/LOP) that is being designed for in this project. Choose the first bracketed items, low

hazard rating/very low level of protection for inhabited building occupancy as defined in UFC 4-010-01 (Table B-1). Choose the second bracketed items, very low hazard rating/low level of protection for primary gathering/billeting building occupancy as defined in UFC 4-010-01 (Table B-1). Dynamic analysis is preferred because it typically yields a more appropriate and economical / efficient design. The values for input into the blanks in the following paragraph related to 'ductility ratio' and 'maximum support rotation' (for the appropriate level of protection - very low, low) for steel and aluminum framing/mullions can be found in Engineering Technical Report (PDC TR-10-02) titled Blast Resistant Design Methodology for Window Systems Designed Statically and Dynamically at USACE Protective Design Center (Website link: pdc.usace.army.mil/library/tr/10-02). This section must be completed by an engineer experienced in blast-resistant design.

****

Design window assembly using a dynamic analysis to prove the system will provide performance equivalent to or better than a [low;] [very low;] [_____] hazard rating in accordance with ASTM F2912 for the peak positive pressure of [_____] kilopascals (kPa) [_____] pounds per square inch (psi) and peak positive phase impulse of [_____] kilopascal-millisecond (kPa-msec) [_____] pounds per square inch - millisecond (psi-msec). Use a triangular blast load using the applicable pressure and impulse indicated above. The allowable response limits of [aluminum] [steel] frame elements are as follows: Maximum ductility ratio of [_____] and maximum support rotation of [_____] degrees.

1.8.2.3 Standard Airblast Test Method

****

NOTE: The blanks in the following paragraph should be the value of the peak positive pressure and impulse for the explosive weight and standoff distance combination (based on the established DBT/LOP) that is being designed for in this project. Choose the first bracketed items, low hazard rating/very low level of protection for inhabited building occupancy as defined in UFC 4-010-01. Choose the second bracketed items, very low hazard rating/low level of protection for primary gathering building occupancy as defined in UFC 4-010-01. This section must be completed by an engineer experienced in blast-resistant design.

****

As an alternative to the 'Computational Design Analysis Method' and 'Dynamic Design Analysis Method' indicated above, window [_____] assembly may be tested for evaluation of hazards generated from airblast loading in accordance with ASTM F1642/F1642M by an independent testing agency regularly engaged in blast testing. For proposed window systems that are of the same type as the tested system but of different size, the test results may be accepted provided the proposed window size is within the range from 25 percent smaller to 10 percent larger in area and aspect

ratio of the original qualified tested glazing systems in accordance with ASTM F2912. Proposed window system/assembly of a size outside this range will require testing to evaluate their hazard rating or are certified by the 'Dynamic Design Analysis Method' indicated above. Testing may be by shock tube or arena test. Perform the test on the entire proposed window system/assembly, including, the glazing, its framing/support system, operating devices, and all anchorage devices. Window support system replicate anchorage of the window support system with the method of installation to be used for the project. The minimum airblast loading parameters for the test will be as follows: peak positive pressure of [_____] kilopascals (kPa) [_____] pounds per square inch (psi) and peak positive phase impulse of [_____] kilopascal-millisecond (kPa-msec) [_____] pounds per square inch - millisecond (psi-msec). The hazard rating for the proposed window systems, as determined by the rating criteria of ASTM F2912, to provide performance equivalent to or better than a [low;] [very low;] [_____] hazard rating (i.e. the "No Break", "No Hazard", "Minimal Hazard", "Very Low Hazard" and "Low Hazard" ratings are acceptable. "High Hazard" ratings are unacceptable. Results of window systems previously tested by test protocols other than ASTM F1642/F1642M may be accepted provided the required loading, hazard level rating, and size limitations stated herein are met.

]1.8.3 Air Infiltration

Air infiltration must not exceed the amount established by AAMA/WDMA/CSA 101/I.S.2/A440 for each window type.

1.8.4 Water Penetration

Water penetration must not exceed the amount established by AAMA/WDMA/CSA 101/I.S.2/A440 for each window type.

1.8.5 Thermal Performance

****

NOTE: Window properties are critical to energy performance and comfort. Specify low U value (rate of heat transfer) to reduce winter heat loss and summer heat gain.

Energy Star labeling is applicable to residential units only.

For nonresidential applications, refer to UFC 1-200-02, High Performance and Sustainable Building Requirements, for minimum requirements for energy efficiency and meeting minimum building envelope requirements of UFC 3-101-01 including fenestrations and glazing.

Coordinate with Section 08 81 00 GLAZING. Designer must verify availability and adequate competition for products meeting bracketed energy performance requirements before specifying and edit as needed.

****

Windows (including frames and glass) will be independently tested and certified with a Solar Heat Gain Coefficient (SHGC) determined according to NFRC 200 procedures and a whole window U-factor determined in

accordance with NFRC 100 within the ranges as indicated below according to the ASHRAE 169 Climate Zone of the project location.[Windows used solely within the interior of a conditioned envelope are exempted from meeting U-Factor and SHGC requirements, unless otherwise noted.] Provide visual Transmittance (VT) of 0.5 or greater. Submit documentation supporting compliance with Energy Star, FEMP designated, and Passive House qualifications as applicable. Provide proof of Energy Star label for residential aluminum window products.

[1.8.5.1 Southern Climate

Windows installed in Climate Zone [1] [2] will have a U-Factor of [1.3] [1.25] [_____] $W/m^2 \cdot$degrees C [0.40] [_____] $BTU/h \cdot ft^2 \cdot$degrees F or less and a SHGC of [0.25] [_____] or less.

][1.8.5.2 South-Central Climate

Windows installed within Climate Zone 3 will have a U-Factor of [0.85] [1.25] [_____] $W/m^2 \cdot$degrees C [0.30] [_____] $BTU/h \cdot ft^2 \cdot$degrees F or less and a SHGC of [0.25] [_____] or less.

][1.8.5.3 North-Central Climate

Windows installed within Climate Zone 4 will have a U-Factor of [0.85] [1.25] [_____] $W/m^2 \cdot$degrees C [0.30] [_____] $BTU/h \cdot ft^2 \cdot$degrees F or less and a SHGC of [0.36] [_____] or less.

][1.8.5.4 Northern Climate

Windows installed within Climate Zone [5] [6] [7] will have a U-Factor of [0.65] [1.25] [_____] $W/m^2 \cdot$degrees C [0.27] [_____] $BTU/h \cdot ft^2 \cdot$degrees F or less and a SHGC of [0.36] [0.41] [_____] or less.

][1.8.5.5 Subarctic Climate

Windows installed within Climate Zone 8 will have a U-Factor of [0.45] [1.25] [_____] $W/m^2 \cdot$degrees C [0.08] [0.22] [_____] $BTU/h \cdot ft^2 \cdot$degrees F or less. There is no SHGC limit for this climate zone.

]1.8.6 Windborne-Debris-Impact Performance

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NOTE: Retain WINDBORNE-DEBRIS-IMPACT RESISTANCE paragraph if required by Project. The UFC 1-200-01 DoD Building Code cited IBC defines windborne debris regions. Enhanced protection applies to essential facilities. Verify site specific requirements with the AHJ. Delete items not required.

****

Exterior window system including glazing must comply with indicated basis or enhanced protection testing requirements in ASTM E1996 for [Wind Zone 1] [Wind Zone 2] [Wind Zone 3] [Wind Zone 4] when tested according to ASTM E1886. Test specimens must be no smaller in width and length than glazing indicated for use on Project and must be installed in same manner as glazing indicated for use on Project.

a. Refer to drawings for classification of window requiring basic or

enhanced protection.

[b. Large-Missile Test: For glazing located within 9.1 m 30 feet of grade.

][c. Small-Missile Test: For glazing located more than 9.1 m 30 feet above grade.

]1.9 WARRANTY

Provide Manufacturer's standard performance guarantees or warranties that extend beyond a 1 year period.

PART 2 PRODUCTS

2.1 WINDOW UNITS

Primed window frames must conform to AAMA/WDMA/CSA 101/I.S.2/A440 and the requirements specified herein. Provide windows of types, grades, performance classes, combinations, and sizes indicated or specified. Provide windows to accommodate hardware, glass, weatherstripping and accessories. Each window must be a complete factory-assembled unit with glass factory or field installed.

2.2 WEATHERSTRIPPING

Weatherstripping must conform to AAMA/WDMA/CSA 101/I.S.2/A440.

2.3 GLASS

Use ASTM C1048 and ANSI Z97.1 Grade B (tempered), Style I (uncoated), Type 2, Class [1 (transparent)] [2 (heat absorbing)].

2.4 SETTING MATERIALS

Provide types required for the applicable setting method specified in the GANA Glazing Manual, unless specified otherwise herein. Do not use metal sash putty, non-skinning compounds, nonresilient preformed sealers, or impregnated preformed gaskets. Materials exposed to view and unpainted must be [gray,] [black] or neutral color.

2.4.1 Elastomeric Sealant

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NOTE: Where Section 07 92 00 JOINT SEALANTS is included in the specifications select the first bracketed option; if this section not included, select second option.

****

[See Section 07 92 00 JOINT SEALANTS for sealant requirements.] [ASTM C920, Type S or M, Grade NS, Class 12.5, Use NT. Use for channel or stop glazing [and] [metal] sash. Sealant must be chemically compatible with setting blocks, edge blocks, and sealing tapes. Color of sealant must be [as selected] [gray] [black] [white] [_____].]

2.4.2 Sealing Tapes, Beads or Gaskets

Gaskets or beads must be at least 9.5 mm 3/8 inch wide with a Shore "A" durometer hardness of 50 and conform to ASTM C509.

2.4.3 Setting Blocks and Edge Blocks

Use neoprene of 70 to 90 Shore "A" durometer hardness, chemically compatible with sealants used, and of sizes recommended by the glass manufacturer.

2.4.4 Accessories

Use accessories as required to provide a complete installation, including glazing points, clips, shims, angles, beads, and spacer strips. Provide noncorroding metal accessories. Provide primer-sealers and cleaners as recommended by the glass and sealant manufacturers.

2.5 WINDOW ASSEMBLIES

Window units must conform to AAMA/WDMA/CSA 101/I.S.2/A440.

2.5.1 Provisions for Glazing

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NOTE: Edge clearances, face clearances, and bites must be maintained as shown below:

Minimum Clearance and Bite Requirements			
Glass Thickness (mm)	**"A" Minimum Edge Clearance (mm)**	**"B" Nominal Bite (mm)**	**"C" Minimum Face Clearance (mm)**
6.0	**6.0**	**13.0**	**3.00**
8.0	**8.0**	**13.0**	**4.75**
10.0	**8.0**	**13.0**	**4.75**
12.0	**9.5**	**13.0**	**6.00**
16.0	**9.5**	**13.0**	**6.00**
19.0	**9.5**	**13.0**	**8.00**
22.0	**13.0**	**16.0**	**8.00**
25.0	**13.0**	**19.0**	**9.50**

Minimum Clearance and Bite Requirements			
Glass Thickness (in)	"A" Minimum Edge Clearance (in)	"B" Nominal Bite (in)	"C" Minimum Face Clearance (in)
1/4	1/4	1/2	1/8
5/15	5/16	1/2	3/16
3/8	5/16	1/2	3/16
1/2	3/8	1/2	1/4
5/8	3/8	1/2	1/4
3/4	3/8	1/2	5/16
7/8	1/2	5/8	5/16
1	1/2	3/4	3/8

****

Provide windows and rabbets suitable for specified glass thickness.[Minimum edge clearance must be [_____]. Nominal bite must be [_____]. Minimum face clearance must be [_____].] Provide sash for glazing and for securing glass with [metal beads] [glazing clips] [glazing channels] and glazing compound.

2.5.2 Sealant, Gaskets, and Beads

Sealant, gaskets, and beads must be continuous around the perimeter of the glass.

2.5.3 Weatherstripping

Provide for ventilating sections of windows to ensure a weathertight seal meeting the infiltration requirements specified in AAMA/WDMA/CSA 101/I.S.2/A440. Provide factory-applied weatherstripping that can be replaced by field repair mechanics. Use molded vinyl, molded or molded-expanded neoprene for weatherstripping for compression contact surfaces. Do not use neoprene or polyvinyl chloride weatherstripping where it will be exposed to direct sunlight.

2.5.4 Fasteners

Provide flathead, cross-recessed type, exposed head screws and bolts with standard threads for use on windows, trim, and accessories. Screw heads must finish flush with adjoining surfaces. Screws and bolts exposed to the environment to be corrosion resistant coated steel, aluminum, or stainless steel compatible with the window material and adjoining construction, and of a type and size recommended by the manufacturer to meet the performance requirements. Self-tapping sheet-metal screws are not acceptable for material more than 1.59 mm 1/16 inch thick.

2.5.5 Drips and Weep Holes

Provide continuous drips over heads of top ventilators. Where fixed windows adjoin ventilators, drips must be continuous across tops of fixed windows. Provide drips and weep holes as required to return water to the outside.

2.5.6 Combination Windows

Windows used in combination must be the same grade and performance class and must be factory assembled. Where factory assembly of individual windows into larger units is limited by transportation considerations, prefabricate, match mark, transport, and field assemble.

2.5.7 Accessories

Provide windows complete with necessary hardware, fastenings, clips, fins, anchors, glazing beads, and other appurtenances necessary for complete installation and proper operation.

2.5.8 Hardware

The item, type, and functional characteristics must be the manufacturer's standard for the particular window type and must conform to AAMA/WDMA/CSA 101/I.S.2/A440. Provide hardware that functions after the window assembly has withstood the application of the design blast pressure causing the development of a static design resistance, ru, uniformly applied over both glazing and frame as defined in paragraph CERTIFICATES OF COMPLIANCE of this section. Equip operating ventilators with a lock or latching device which can be secured from the inside.

2.5.9 Anchors

Provide concealed anchors of the type recommended by the window manufacturer for the specific type of construction. Provide corrosion resistant anchors and fasteners compatible with the window and the adjoining construction. Provide a minimum of three anchors for each jamb located approximately 150 mm 6 inches from each end and at midpoint.

2.5.10 Window Cleaner Anchors

****

NOTE: Windows having sills more than 13.7 meters 45 feet above grade, adjoining balconies, or adjoining roofs should be shown and specified as requiring window cleaner anchors, unless window cleaning methods at the activity make use of these anchors on lower windows. Coordinate window cleaning procedures and requirements with the using activity in making the decision as to the need for window cleaner anchors. No removable or tilting-type sash may be provided instead of the anchors.

****

Provide double-head anchors for windows [indicated] [specified]. Anchors must be stainless steel of size and design required for the window type and application. Provide two anchors for each single window[and each adjacent glass window unit]. Fasten anchors 1120 mm 44 inches above the window sill utilizing appropriate methods for the window type and

application in accordance with industry safety standards.

2.5.11 Finishes

****

NOTE: Specify anodic and organic coatings meeting the selection requirements in the Notes below as Contractor's option when these finishes are determined to be available in the desired colors and economically competitive in the project area, unless the project requires use of one or the other to match an existing condition. The selection of anodic or organic coating is based primarily on the desired appearance: anodized finishes provide a metallic appearance and organic finishes provide a painted or metal-like finish (organic finishes are available in a variety of colors). Only allow both types as a Contractor option when the Designer confirms that the desired appearance is available in both types of finishes.

****

Exposed aluminum surfaces must be factory finished with an [anodic coating] [or] [organic coating].[Color must be [_____] [as indicated].] Windows [for each building] must have the same finish.

2.5.11.1 Anodic Coating

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NOTE: Specify Architectural Class I for harsh atmospheres where dust, gases, salts, and other destructive elements will attack metal finish. Also specify Class I for humid locations or project locations with Environmental Severity Classifications (ESC) of C3 thru C5. Humid locations are those in ASHRAE climate zones 0A, 1A, 2A, 3A, 3C, 4C and 5C (as identified in ASHRAE 90.1). Specify Architectural Class II for all atmospheric conditions not requiring Class I. See UFC 1-200-01 for determination of ESC for project locations.

****

Clean exposed aluminum surfaces and provide an anodized finish conforming to AA DAF45 and AAMA 611. Finish must be:

[a. Architectural Class II (0.01 to 0.0175 mm 0.4 mil to 0.7 mil), designation AA-M10-C22-[A31, clear (natural)] [A32, integral color] [A34, electrolytically deposited color] anodized.

][b. Architectural Class I (0.0175 mm 0.7 mil or thicker), designation AA-M10-C22-[A41, clear (natural)] [A42, integral color] [A44, electrolytically deposited color] anodized.

]2.5.11.2 Organic Coating

****

NOTE: For organic coatings, to provide enhanced resistant to corrosion, weathering, ozone, and UV

radiation utilize superior performance powder coat finishes conforming to AAMA 2605 in humid locations and project locations with an ESC of C3 thru C5; baked enamel finishes conforming to AAMA 2603 may be utilized for non-humid locations and ESC C1 or C2 project locations. Humid locations are those in ASHRAE climate zones 0A, 1A, 2A, 3A, 3C, 4C and 5C (as identified in ASHRAE 90.1). Refer to UFC 1-200-01 for determination of ESC for a specific project location.

****

Clean and prime exposed aluminum surfaces. Provide a [baked enamel finish in accordance with AAMA 2603 with total dry film thickness not less than 0.02 mm 0.8 mil] [superior performance finish in accordance with AAMA 2605 with total dry film thickness of not less than 0.03 mm 1.2 mils].

2.6 SOURCE QUALITY CONTROL

2.6.1 Window Assembly Structural Test

2.6.1.1 Test Sample Number

At least two sample window assemblies for each type of window provided must be tested, under an increasing uniform static load. Number of samples, beyond two, is left up to the vendor. However, it is noted that the acceptance criteria encourages a larger number of test samples.

2.6.1.2 Test Procedure

****

NOTE: To assure receiving the desired blast resistance protection, window assemblies provided by Contractor must be exactly as specified. If deviations from the specified requirements are sought by the Contractor, the Contractor must perform acceptance testing for the provided blast resistant window assemblies.

****

Test windows (glass panes and support frame) must be identical in type, size, sealant, gasket or bead and construction to those furnished by the window manufacturer. The frame assembly in the test setup must be secured by boundary conditions that simulate the adjoining walls of the structure for intended installation. The simulation securing boundary conditions must be verified and attested by an attending Professional Engineer. Using either a vacuum or a liquid-filled bladder, an increasing uniform load must be applied to the entire window assembly (glass and frame) until failure occurs in either the glass or frame. Failure must be defined as either breaking of glass or loss of frame resistance. The failure load, rf, must be recorded to three significant figures. The load should be applied at a rate of 0.5 ru per minute where ru is the static design resistance:

Glass Size	Static Design Resistance
[_____] by [_____] mm [_____] by [_____] inch	[_____] kPa [_____] psi

2.6.1.3 Acceptance Criteria

The static load capacity (rs) of a glass pane for the specified acceptance test procedure is:

rs = 0.876 ru (1)

The window assembly (frame and glass) is considered acceptable when the arithmetic mean of all the samples tested, r- such that:

r- => rs plus sA (2)

where: rs = static load capacity of the glass pane for certification testing
s = sample standard deviation
A = acceptance coefficient (Table 1)

a. Arithmetic mean/standard deviation: For n test samples, r- is defined as:

r- = sum from i = 1 thru n for rfi divided by n (3)

where rfi is the recorded failure load of the ith test sample.

The sample standard deviation, s, is defined as:

s = the square root of the quantity of the sum from i = 1 thru n for (rfi - r-2) divided by (n - 1) (4)

The minimum value of the sample standard deviation, s, permitted to be employed in Equation (2) is:

s = 0.145 rs (5)

This assures a sample standard deviation no better than observed for the general population of tempered glass.

b. Additional sampled determination: The following equation can be used by tester to determine if additional test samples are justified. If:

r- =< rs plus sB (6)

then with 90 percent confidence, the design will not prove to be adequate with additional tests. Obtain rejection coefficient, B, from Table 1.

Table 1. Statistical Acceptance and Rejection Coefficients		
Number of Window Assemblies, n	Acceptance Coefficient, A	Rejection Coefficient, B
2	4.14	.546
3	3.05	.871
4	2.78	1.14
5	2.65	1.27
6	2.56	1.36
7	2.50	1.42
8	2.46	1.48
9	2.42	1.49
10	2.39	1.52
11	2.37	1.54
12	2.35	1.57
13	2.33	1.58
14	2.32	1.60
15	2.31	1.61
16	2.30	1.62
17	2.38	1.64
18	2.27	1.65
19	2.27	1.65
20	2.26	1.66
21	2.25	1.67
22	2.24	1.68
23	2.24	1.68
24	2.23	1.69

Table 1. Statistical Acceptance and Rejection Coefficients		
Number of Window Assemblies, n	Acceptance Coefficient, A	Rejection Coefficient, B
25	2.22	1.70
30	2.19	1.72
40	2.17	1.75
50	2.14	1.77

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Method of Installation

Install in accordance with the window manufacturer's printed instructions and details. Set windows at proper elevation, location, and reveal. Brace properly to prevent distortion and misalignment. Bed screws or bolts in sill members, joints at mullions, contacts of windows with sills, built-in fins, and subframes in mastic sealant of a type recommended by the window manufacturer. Install windows in a manner that will prevent entrance of water. Fasten hardware to windows.

3.1.2 Glass Setting

Items to be glazed must be either shop or field glazed using glass of the quality and thickness specified or indicated. Preparation and glazing, unless otherwise approved, must conform to applicable recommendations in the GANA Glazing Manual. Windows may be glazed in conformance with one of the glazing methods described in the standards under which they are produced, except that face puttying with no bedding will not be permitted. Handle and install glazing materials in accordance with manufacturer's instructions. Use beads or stops furnished with items to be glazed, to secure glass in place.

3.1.3 Dissimilar Materials

Where aluminum surfaces are in contact with, or fastened to, masonry, wood, or dissimilar metals, except stainless steel or zinc, the aluminum surface must be protected from dissimilar materials as recommended in the Appendix to AAMA/WDMA/CSA 101/I.S.2/A440. Do not coat surfaces on which sealants are to adhere.

3.1.4 Anchors and Fastenings

Make provision for securing units to each other and to adjoining construction.

3.1.5 Adjustments After Installation

After installation of windows and completion of glazing and field

painting, adjust ventilators and hardware to operate smoothly and to provide weathertight sealing when ventilators are closed and locked. Lubricate hardware and operating parts as recommended by the manufacturer.

3.2 CLEANING

Clean interior and exterior surfaces of window units of mortar, plaster, paint spattering spots, and other foreign matter to present a neat appearance, to prevent fouling of weathering surfaces and weatherstripping, and to prevent interference with the operation of hardware. Remove stained, discolored, or abraded windows that cannot be restored to their original condition, and replace with new windows.

3.3 SCHEDULE

Some metric measurements in this section are based on mathematical conversion of English unit measurements, and not on metric measurements commonly agreed to by the manufacturers or other parties. The English and metric units for the measurements shown are as follows:

Products	English Units	Metric Units
Gaskets	3/8 inch	9.5 mm
Glass	1/4 inch	6.0 mm
	5/16 inch	8.0 mm
	3/8 inch	10.0 mm
	1/2 inch	12.0 mm
	5/8 inch	16.0 mm
	3/4 inch	19.0 mm
	7/8 inch	22.0 mm
	1 inch	25.0 mm

-- End of Section --