SECTION 08 04 00 – BLAST RESISTANCE

PART 1  GENERAL

1.1 RELATED SECTIONS

A. Refer to the specific technical specifications sections for additional information regarding the following: Cold-Formed Metal Framing, Structured-Polycarbonate Panel Assemblies, Doors, Glazing, Curtain Walls, Store Front, Windows, Equipment, Pumps, Chillers, Fans, Air Handling Units, Motor Control Centers, and Distribution Panels.

1.2 REFERENCES

A. 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.

ASTM INTERNATIONAL (ASTM)

ASTM A500/A500M (2013) Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes


ASTM F2912 (2011) Standard Test Method for Metal Doors Used in Blast Resistant Applications (Equivalent Static Method)


AMERICAN SOCIETY OF CIVIL ENGINEERS


UNITED FACILITIES CRITERIA

UFC 4-010-01 (2013) DoD Minimum Antiterrorism Standards for Buildings


PROTECTIVE DESIGN CENTER TECHNICAL REPORT


PDC-TR 10-02 (2012) Blast Resistant Design Methodology for Window Systems Designed Statically and Dynamically


1.3 GENERAL RESPONSE CRITERIA
A. General response criteria listed as per the publications listed in the References section.
B. Building Level of Protection
1. The facility is designed in accordance with UFC 4-010-01 and meets the protective compliance and strategies as stated in UFC 4-010-01 and other applicable project documents.
   a) C-17 Shops and Administrative Building (Area A & B per the drawings): Primary Gathering/Low Level of Protection
   b) Simulator Building: Inhabited Building/Very Low Level of Protection
   c) C-17 Hangar Bay Building (Area C, D & E per the drawings): Low Occupancy
   d) Fire Pump House Building: Low Occupancy

C. Level of Protection Performance
   1. Glazing will fracture, remain in the frame and results in a minimal hazard consisting of glass dust and slivers (Minimal hazard rating)
   2. Doors will experience non-catastrophic failure, but will have permanent deformation and may be inoperable (Category III).

D. Mandatory Compliance References
      a) Applicable UFC 4-010-01 Standards (s): B-3.1 Standard 10. Windows & Skylights
      b) Standard 12- Exterior Doors
      c) Standard 19- Equipment Bracing

1.4 HAZARD RESISTANT GLAZING
   A. Glazing: Heat Strengthened (HS) or fully tempered. Glazing shall consist of single laminated panes, insulating glass units (IGUs) with a laminated inner pane (and outboard pane if required for design loads), glass-clad polycarbonate, or laminated plastics in compliance with UFC 4-010-01 Standard 10.

1.5 SYSTEM DESCRIPTION
   A. Blast resistant doors and window systems are scheduled on the architectural drawings. The requirements listed in this section are performance standards related to blast resistance. Where blast resistance is a design consideration, the requirements of this section shall be met in addition to all other requirements from the main product specification sections. Each door assembly shall include the door, frame, anchors, hardware, and accessories and shall be provided by a single manufacturer. Frames and anchors for doors and windows systems shall be capable of transferring blast and rebound reactions to the adjacent supporting structure. Resistance to blast shall be demonstrated either by design calculations or tests on prototype door assemblies.

1.6 ADMINISTRATIVE REQUIREMENTS
   A. Section 01: Project management and coordination procedures.
   B. Coordination:
      1. Coordinate with other work having direct bearing on work of this section.
2. Coordinate the work of this section with all sections referencing this section.

1.7 SUBMITALS FOR REVIEWS

A. Section 01: Submission procedures.

B. Shop Drawings: Drawings showing complete details of the proposed setting methods, mullion details, edge blocking, size of openings, frame details, bracing, materials, and types and thickness of glass.

C. Design Data: Submit design analysis with calculations showing that the design of each different size and type of unit and its anchorage to the structure meets the minimum performance requirements of this section, unless conformance is demonstrated by Test results. Calculations verifying the structural performance of each unit proposed for use, under the given loads, shall be prepared and signed by a registered Professional Engineer. The unit components and anchorage devices to the structure, as determined by the design analysis, shall be reflected in the shop drawings. All calculations shall be signed and sealed by a Professional Engineer and submitted for review and approval.

D. Test Reports: For blast resistant windows, in lieu of a Design Analysis, results of airblast testing, whether by arena test or shocktube, shall be included in a test report, providing information in accordance with ASTM F2247, as prepared by the independent testing agency performing the test. The test results shall demonstrate the ability of each unit proposed for use to withstand the airblast loading parameters and achieve the hazard level rating in accordance with ASTM F2912 specified in paragraph "Standard Airblast Test Method". Test report is to be stamped and signed by a Professional Engineer whose qualifications meet or exceed Quality Assurance criteria and/or certified by an accredited ASTM testing laboratory.

E. Certificates:

1. Engineer's qualifications that meet or exceed Quality Assurance criteria. At a minimum, qualifications must list each project in which the Engineer performed dynamic analysis of similar systems, the effective start and end dates of performance of the analysis and a reference.

2. Steel mill reports covering the number, chemical composition and tension properties for structural quality steels shall also be submitted.

3. When blast resistance is demonstrated by calculations, a certificate stating that the system assembly provided was manufactured using the same materials, dimensions, tolerances shown in calculations. When blast resistance is demonstrated by prototype testing, a certificate stating that the stem assembly provided was manufactured using the same materials, dimensions, tolerances as the tested prototype and connections or frame anchors is required.

1.8 QUALITY ASSURANCE

A. Qualifications: If dynamic analysis is performed, engage a licensed engineer with a minimum of 5 years’ experience in blast resistant design and demonstrable experience designing blast resistant door/window systems in the past 18 months.

B. Shop Drawing Requirements: Provide drawings that indicate elevations of doors/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, installation details, bracing, and other related items.

C. Design Data Requirements: Submit calculations to substantiate compliance with specified Performance criteria. A registered Professional Engineer must provide calculations.

1. Submit design analysis with calculations showing that the design of each different size and type of unit and its anchorage to the structure meets the requirements of paragraph "Performance Criteria" under testing or dynamic design methods.

a) Structural Calculations

1) Prior to performing engineering calculations, submit a description of technique(s) that shall be employed to calculate the response of the system to the defined loading.

2) Calculation package is to include a summary sheet briefly outlining the following:
   1. Evaluation criteria
   2. Calculation assumptions
   3. Table of results by door type/location
   4. Statement of Conformance with specification requirements

3) Calculation submittal is to be stamped and signed by a registered Professional Engineer whose qualifications meet or exceed that of the Quality Assurance section of this specification.

4) Submit single degree of freedom or other approved dynamic analysis method calculations.

5) Anchorage: Analyze the strength of embedded anchor assembly, as well as pull-out and reaction forces shared with the building structure. Include exact loadings to be transferred to the building structure in the analysis.

6) Mechanical Anchors: Mechanical anchor capacities shall be developed from dynamic testing. A Code evaluation report showing testing for dynamic loading (i.e. seismic or blast) is to be submitted with calculations.

7) Supporting Structure: Coordination of the supporting structure interaction shall be the contractors’ responsibility. The contractor's engineer performing blast calculations shall coordinate loading scenarios with the cladding contractor's engineer providing the design for the exterior cladding system.

D. Test Report Requirement: Test units are required to be similar to the project units. Identical mullion shapes, glass lay-up, door distribution and anchorage system are required between test doors and project doors. Glass pane areas and mullion spans for the project doors are required to be within 10% of the test doors.

1. Test Report Package
a) Test report package is to include a summary sheet briefly outlining the following:
   1) Brief description of the test performed
   2) Table of test results by door type/location
   3) Table of comparison between test doors and project doors
   4) Statement of Conformance with ASTM F1642 with hazard ratings in accordance with ASTM F2912.
   5) In addition, test reports must include all the information required by ASTM F1642 Section 12.

b) Test report is to be stamped and signed by a registered Professional Engineer whose qualifications meet or exceed Quality Assurance criteria and/or certified by an accredited ASTM testing laboratory.

1.9 BLAST LOADING
A. The design air blast loading for both testing and analysis will be the appropriate pressure and impulse from the applicable design explosive event. Air blast loading is listed as follows:

   1. C-17 Shops and Administrative Building (Area A, B & C per the drawings):
      Air blast loading shall be per UFC 4-010-01 with Explosive Weight II at 30 feet standoff distance typical.
   2. Simulator Building: Air blast loading shall be per UFC 4-010-01 with Explosive Weight II at 30 feet standoff distance typical.

1.10 PERFORMANCE REQUIREMENTS
A. Door Requirements
   1. All exterior doors shall meet the minimum requirements indicated below and blast loading specified.
      a) Doors:
         Provide doors that are tested to achieve the applicable performance of Category III per UFC 4-010-01, ASCE Blast-Resistant Design and in accordance with ASTM F2247 or ASTM F2927 or that are analyzed dynamically using the approach described in the following Section.
         Fasteners and anchorage methods used to attach the tested door assembly will be representative of the actual door installation. Any deviations in actual installation of the connections or the connected elements from those tested must be demonstrated by calculation to provide the required level of protection for the specific application.

      b) Dynamic Door Analysis:
         As an alternative, blast doors may be designed dynamically to demonstrate through calculations that the door shall remain in its frame.
1) Elements may be designed to experience excessive permanent deformations but shall not pose a flying projectile hazard in response to the specified blast loading.

2) The door will experience non-catastrophic failure, but will have permanent deformation and may be inoperable. The applicable performance of Category III per UFC 4-010-01, ASCE Blast-Resistant Design.

3) Connections shall be designed to develop the flexural capacity of the element being connected.

B. Window Systems Requirements

1. All exterior glazed openings shall meet the minimum requirements indicated below and the specified blast loading parameters. Window systems may be designed using static or dynamic analysis, or established by testing.

   a) Glazing

      Provide glazing thickness and lay-up that are tested to performance to a Hazard Level H2 (Minimal hazard rating) per ASTM F2912 when tested in accordance with ASTM F1642. Glazing system shall meet a minimum Specification Level Z2 with the specified blast loads.

   b) Static Analysis

      Static analysis in accordance with ASTM F2248 and ASTM E1300 is permitted. Frames and their connections may be designed using LRFD procedures with load factors and strength reduction factors taken as unity.

      Frame members designed statically shall be limited to deflections not more than 1/60 of the length of the glazing supported edge, regardless of anchor spacing, when subjected to a load equal to two times the glazing resistance determined from ASTM E1300. Members shall be checked based on section properties determined from the design strength calculations under loading equal to two times the glazing resistance at yield strength of the frame material.

      Connections for window systems shall be designed for two times the load resistance of the glazing determined from ASTM E1300 when the capacity of the glazing is more than two times the specified design air blast pressure; otherwise, connections may be designed for the load resistance of the glazing determined from ASTM E1300. Connection design shall consider edge distance, spacing, embedment depth, material strength, etc. required to fully develop the connectors. Strength reduction factors shall be taken from the appropriate material codes for all connection designs.

   c) Dynamic Analysis

      Dynamic analysis using computer programs recognized by the blast design community is permitted. Glass design for blast effects shall be based on a maximum probability of glass breakage of 500 breaks per
1000. Post-failure performance of the window system shall be assessed using industry-standard computer programs or verified by blast testing in accordance with Section 10.6 of ASCE 59-11.

Connections and anchorage systems shall be designed to resist the smaller of the following two static loads:

1) The ultimate flexural resistance of the frame components;
2) The peak dynamic reactions from the frame.

Connection design shall consider edge distance, spacing, embedment depth, material strength, etc. required to fully develop the connectors. Strength reduction factors shall be taken from the appropriate material codes for all connection designs.

C. Interior Equipment Bracing

1. Interior equipment bracing shall be designed and detailed to reduce the potential for producing hazardous secondary fragments due to the specified explosive threats, consistent with the designated level of protection.

2. Interior equipment bracing
   a) Mount all overhead utilities and other fixtures weighing 31 pounds or more (excluding distributed systems such as piping networks that collectively exceed that weight) using either rigid or flexible systems to minimize the likelihood that they will fail and injure building occupants.
   Design all equipment mountings to resist forces of 0.5 times the equipment weight in any horizontal direction and 1.5 times the equipment weight in the downward direction. This standard does not preclude the need to design equipment mountings for forces required by other criteria such as seismic standards.

PART 2 PRODUCTS

2.1 MATERIALS

A. Metals

1. Framing members: Use extruded aluminum sections or continuous structural steel sections.
   a) Yield strength: Provide supporting references that grade of steel or aluminum used is capable of achieving calculated ductility ratio.
      1) Structural Steel:
         1. Structural tubing shall conform to ASTM A500/A500M, ASTM A1085, ASTM A501, or ASTM A618/A618M.
         2. Structural steel bars, plates and shapes shall conform to ASTM A36/A36M.
         3. Sheet steel and strip shall conform to ASTM A653/A653M.
      b) If dynamic analysis is used, the yield strength of doors, mullions and frame elements may be increased to account for strain rate effects. The
strength increase factor (SIF) and dynamic strength increase factor (DIF) per PDC-TR 06-01 may be utilized.

c) Section Modulus: The plastic section modulus may be used in dynamic design analysis.

d) Built-up Sections: Section properties of a built-up member consisting of individual components of the same or a combination of materials (i.e. steel and aluminum) shall be determined based on the following:

1) Ultimate stress and strain compatibility between individual member components shall be accounted for through industry standard methods of analysis.

2) Composite section properties may only be used if calculations demonstrate deformation full shear stress transfer along the line of contact between individual members components.

3) Combined section properties may only be used if calculations demonstrate deformation compatibility between aluminum and steel components.

e) Hardware: In the absence of a continuous door stop, hinges and other mechanical hardware shall provide a load path from the door leaf to frame/mullion and be manufactured to support the door and resist blast induced loading. Hardware is not required for resistance of rebound loading as the door leaf may fail outward away from the building.

PART 3 EXECUTION (NOT APPLICABLE)

END OF SECTION 08 04 00