

Specification Section 08 39 53
Blast Resistant Swing Door Unit PDI Model DB-X to withstand Dynamic Blast Load

PART 1 – GENERAL

1.1 Scope

- A. This specification covers the requirements to design and fabricate blast resistant steel door assemblies where indicated on door schedule and specified for _____ in _____. The room /or/ building is located in an area that could receive a blast wave from an explosion accident.
- B. Section Includes:
 - 1. Specification covers PDI swing doors Model DB-X to resist dynamic blast load.
 - 2. Blast resistant steel door, steel frame and blast door manufacturer's hardware.
 - 3. The building design allows for the door types listed in Table 1.

Table 1: Door Types

Type	Jamb Opening (Width x Height)	Quantity
A – Single Man Door		
B – Pair of Doors		
C - Other		

- C. The blast pressure each door must resist is provided in Part 2 of this specification. After the explosion, the door is to remain operable from the inside to allow egress from the room or building, either Response Category I or II. Specify if door panel is to be seated into frame by the event of an explosion or unseated against hardware. Door shall remain latched and will not open on the rebound.
- D. Furnish blast resistant door assembly consisting of steel door leaf, steel frame, frame anchorage, hinge(s), latchset, latchbolt pins and associated hardware including closing device, weatherstripping and threshold. The door system shall be side hinged, swinging type.
- E. The door frame shall be cast into reinforced concrete wall /or/ welded onto a steel sub-frame or steel plate embedded into adjacent wall construction. Sub-frame / embed to be analyzed, supplied and installed by contractor or another entity. The intent of providing separate sub-structure is to allow wall construction of the facility to proceed during fabrication of the blast doors. Door installation can take place near the completion of construction.
 All structural openings shall be field verified by contractor prior to fabrication. In cases where the walls are not erected, contractor shall verify that the structural opening dimensions shall be maintained.

1.2 References

- A. Biggs, J.M., *Introduction to Structural Dynamics*, McGraw Hill Book Company, New York, NY, 1964.
- B. *Design of Blast Resistant Buildings in Petrochemical Facilities*, Second Edition, prepared by the Task Committee on Blast Resistant Design, Published by American Society of Civil Engineers (ASCE), 2010.
- C. Harris, C.M. and Crede, C.E., "Shock and Vibration Handbook", McGraw-Hill Book Company, Volume 3, 1961.
- D. NFPA 101, "Life Safety Code".
- E. PIP ARS08390, "Blast Resistant Doors, Frames, and Related Hardware Specification", Process Industry Practices (PIP) Architectural, Construction Industry Institute, The University of Texas at Austin, June 2013.
- F. PIP STC01018, "Blast Resistant Building Design Criteria", Process Industry Practices (PIP), Construction Industry Institute, The University of Texas at Austin, October 2014.
- G. "Structural Analysis and Design of Nuclear Plant Facilities", American Society of Civil Engineers, 1980.
- H. "Structural Welding Code", AWS D1.1, latest edition.
- I. UFC 3-340-02, "Structures to Resist the Effects of Accidental Explosions", Unified Facilities Criteria, December 2008 (formerly Dept. of the Army Technical Manual TM5-1300).

1.3 Design Basis

- A. Blast resistant door systems as shown on drawings from a single source shall be **Model DB-X** manufactured by **Protective Door Industries (PDI)**, Harvey, IL 60426 at 708/225-3539, **sales@protectivedoor.com** or prior approved equal.

1.4 Quality Assurance

- A. Door manufacturer shall be certified to ISO quality program ISO 9001:2015.
- B. Welder and weld qualifications, procedures and testing shall be in accordance with AWS D1.1.
- C. Door manufacturer shall be engaged in the successful design and manufacture of blast resistant door assemblies for a minimum of 10 years.

1.5 Submittals

- A. Before fabrication is started, manufacturer shall produce a set of submittal drawings and analysis calculations showing conformance for approval. The submittal shall be sent electronically in '.pdf' format.
- B. Calculations:
 - 1. Analysis calculations shall be based upon Single-Degree-of-Freedom (SDOF) dynamic elastic-plate design techniques under the UFC 3-340-02 'Structures to Resist the Effects of Accidental Explosions' manual. The required resistance for each door assembly shall be based on the P_r peak reflected pressure (or load) and time duration (in msec.), and the maximum allowable response (deformation). Calculations for the hardware covering the operating mechanism, strength of latch pin(s) and hinge(s) are factored in the design to prove the door stays latched in the frame. Connections between blast frame and adjacent construction shall be calculated to ensure frame remains anchored in place during event.
 - 2. Manufacturer shall submit one reproducible copy of analysis calculations printed on 8 ½" x 11" white paper. Calculations shall be clear and concise and done in an organized manner. All terms and variables shall be clearly defined and used consistently throughout the calculations. All references shall be documented. The calculations and all text shall be in English.
Optional: The cover sheet of the calculations shall bear the stamp and seal of a PE Professional Engineer registered in state of Illinois or Pennsylvania.
 - 3. *Alternate:* Shock tube test report performed by an independent testing facility may be submitted instead of calculations providing the criteria and site condition matches.
 - 4. *Alternate:* A Finite Element Analysis (FEA) offers another method to evaluate response loads.
Note: This is expensive and may not be economically practical for door applications.
- C. Drawings:
 - 1. General reference / installation drawings shall be submitted for review before door fabrication begins. All drawings shall be produced in vendor's standard format. The drawings shall be in English. These drawings shall be considered the 'as built' drawings reflecting the final fabricated and installed doors.
 - 2. The design pressure will be specified on drawing along with the seating and unseating stress loads transferred to walls.
 - 3. Drawing shall contain Door Ledger with Mark number(s), door handing, door swing, wall and jamb opening dimensions. Hardware Schedule shall list PDI Sonicbar hardware model number, function and trim; hinge type; door closer model; perimeter gasketing device and threshold. General layout shall detail door elevation, door weight, door thickness, overall door panel and frame construction, transom panel (if required) and frame anchorage.
- D. Product Data: Include information on PDI Sonicbar hardware, hinge(s), door closer, perimeter sealing devices and threshold. Optional equipment may include solenoid (for card reader prep), linear actuator and electric control panel /or/ air cylinder with pneumatic panel (for power operator prep).
- E. Spare Parts: Each complete door assembly is a custom manufactured unit and therefore, no spare part numbers exist for the actual door leaves, frames and hardware. Contact manufacturer to rectify or replace any door or hardware issues.

1.6 Warranty

- A. Blast door manufacturer shall warrant its' products to be free of defects in labor and material for one (1) year after shipment.
- B. The distributor's warranty applies to all outsourced components (i.e. door closer).

PART 2 – DYNAMIC DESIGN REQUIREMENTS

2.1 Blast Loading

- A. The blast loading is uniformly applied to the door’s external surface. P_r peak reflected load, impulse and duration are shown for each door type in Table 2 below. The P_r peak reflected load is assumed to reached instantaneously with a near zero rise time and linearly reduces in magnitude to zero at the time of duration. This is a triangular pulse when the pressure history is plotted as shown in Figure 1.
Note: All doors on building exterior are usually analyzed for one load at same blast pressure.

Table 2. Blast Load Summary

Door Type	P_r Peak Reflected Pressure P_{max} (psi)	Peak Impulse I_{max} (psi-msec)	Total Load Duration T_d (msec)
A			
B			

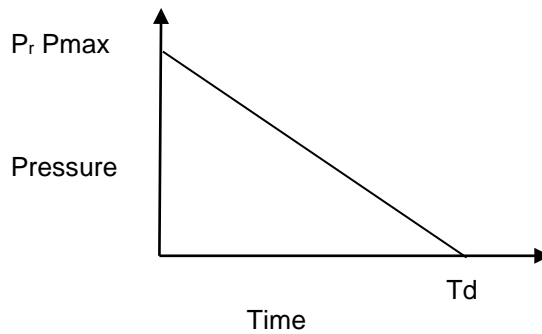


Figure 1. Blast Wave Load-Time History

2.2 Response Criteria

- A. Response criteria for the doors shall meet the requirements of ASCE Standard Level of Protection (LOP) Category I or II /or/ as designated in PIP STC01018 for a Category I response ‘Elastic’ /or/ Category II response ‘Elastic / Significant Damage’ as summarized in Table 3.
Note: Most projects designate Category I or II response level, with exceptions.
- B. Support rotation and the ductility limit shall be computed by door manufacturer and identified in the engineering calculations.

Table 3. Blast Door Response Criteria

Response Category	Door Condition after Blast	Panels	Ductility Limit	Edge/Support Rotation (deg)	Door Function
I	Operable	Elastic Undamaged	Identified and calculated by door vendor	Identified and calculated by door vendor	Primary exit or repeated blasts
II	Operable	Elastic / Significant damage	Identified and calculated by door vendor	Identified and calculated by door vendor	Prevent entrapment

2.3 Blast Door Design

- A. Door system shall be designed to resist P_r peak reflected pressure of _____ PSI at a duration of _____ msec. in the _____ positive phase seating direction (against frame) /or/ _____ unseating direction (against hardware); rebound as calculated. Deflection shall be limited to the yield strength of the materials.
 Door performance shall meet Response Category I /or/ II, and ‘Operable’ following dynamic response to blast load.

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- B. Single-Degree-of-Freedom (SDOF) dynamic elastic-plate design techniques shall be employed with analysis calculations based on UFC 3-340-02 'Structures to Resist the Effects of Accidental Explosions' manual. The pressure-time history shall be included in the analysis.
- C. The dynamic blast pressure shall be qualified as P_r peak reflected load.
 - 1. When P_{so} peak side-on incident pressure is specified, the load will be converted to the reflected load using the ratio increase factor given in UFC 3-340-02, Chapter 2, Figure 2-6.
 - 2. The door system shall be analyzed statically when assembly shall bear a U.L. Fire Label, available up to 10 PSI static equivalent load for standard size swing doors. The dynamic load shall be converted to static equivalent load by multiplying the P_r peak reflected load by the maximum dynamic increase factor (DIF) (normally 2).
- D. The door system shall be designed to resist occurrence of rebound. Maximum rebound forces shall be identified by the door manufacturer in the supporting calculations.
- E. The door system shall be designed to withstand the applied blast loading one time only.
- F. After the explosion, the door shall be operable to allow egress from the room or building. The door panel will be seated /or/ unseated by the explosion and attempt to open in the rebound.
- G. The connection of the concrete wall or sub-frame to the blast frame shall maintain structural integrity throughout all responses to the applied load. Design of this connection is the responsibility of the door manufacturer.

PART 3 – PRODUCT

3.1 Door and Frame Fabrication

- A. Blast door shall be of noncombustible construction, full flush or *optional* vision lite, insulated, fabricated of structural shapes and plates. Faceplate shall be one-piece A36 or A572 Gr50 plate with grade and thickness determined by the design calculations. A non-removable mullion assembly shall be attached to and swing with the inactive leaf of pair at the meeting style. Removable mullions are optional.
- B. Frame shall be A36 formed frame or structural steel channel with welded-on bar stops; three- or four-sided, set-up and welded, factory reinforced with notched cut-outs for hardware. Frame to be equipped with anchorage designed to transfer all blast loadings to adjacent construction or structural embeds. Transom panel (if required) shall be designed to permit complete removal for occasional access of equipment.
- C. Steel material shall conform to the standards of the American Institute of Steel Construction. All work shall be assembled using all welded construction per the standards of AWS D1.1. Welds to be of a size and type as required per the engineering analysis.

3.2 PDI Sonicbar Brand Hardware

- A. Latching hardware and hinge(s) shall be supplied by blast door manufacturer with door construction and hardware analyzed as a complete system. The hardware shall not release under blast load or rebound. Use of builders' hardware shall not be permitted.
- B. Architectural hardware schedule shall designate hardware trim (lever, exit bar device, no exterior trim) on each side of door panel and function (i.e. passage; storeroom or classroom).
- C. Compliance to NFPA 101 operational forces may not be compatible with blast resistant hardware. Blast resistant hardware is heavy duty to withstand the design pressure and carry weight of the door. The blast protection governs the number of latch pins required.
Note: PDI's Sonicbar single-point latchset will meet NFPA 101 operational forces and shall be installed when warranted by the blast condition. (This cannot be specified.) Analysis calculations will determine when one (1) latch pin can be utilized.
- D. All unlocked hardware shall be configured to require only a single operation at either side of door.
- E. The internal latchset parts shall be factory installed. Only the trim and cylinder (if locked) shall be added at site.
- F. Active door latchset:
 - 1. Active door leaf shall use factory installed PDI Sonicbar SH-153 series mortised single-, 2-point or multi-point horizontal spring latch system. Heavy duty hardware assembly shall be corrosion resistant, positive acting, vibration-free and operated by lever handle on outside and lever handle /or/ exit bar on the inside. Doors shall be prepared for key locking cylinder with the master key cylinder provided by others. The hardware trim activates steel latch bolts engaging strikes horizontally at jamb or inactive leaf, and shall not release under blast loads or rebound. Latch bolts (pins) shall have a minimum throw of $1\frac{3}{16}$ " inch. All exposed trim shall be stainless steel with US32D finish. Consult factory for options.

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2. Where scheduled, Sonicbar hardware can be prepared to interface with card key access control device to simulate electric strike function. Builders' electric strike hardware shall not be permitted. Consult factory for details.
3. Where scheduled, Sonicbar hardware can be prepared for power operation activated by either factory installed linear actuator or pneumatic air cylinder. Consult factory for details.
4. Where scheduled, Sonicbar hardware can be arranged for passage function with all security and surface mounted locking components supplied and installed by security vendor or other entity.
- G. Inactive latchset at pair: The inactive leaf shall use factory installed PDI Sonicbar Model SH-154-RB manually operated 2-point vertical latch bolts at head and sill with lever trim at the interior side in stainless steel US32D finish /or/ Sonicbar Model SH-154-FB 2-point vertical manual flush bolts in US26D finish. A sill bolt keeper plate shall be anchored into concrete floor. Consult factory.
- H. Door Closer: A heavy-duty surface mounted door closer can be included at active leaf. Door and frame shall be factory reinforced for door closer. Closer shall be sprayed aluminum finish, BHMA symbol 689.
- I. Hinge(s): Blast door manufacturer shall furnish hinge(s). Door and frame shall be factory reinforced, drilled and tapped, and fitted for hinge(s). Hinge type shall depend upon criteria and door weight.
 1. PDI Sonicbar continuous steel hinge with SS stainless steel pin available in USP prime finish or *optional* SS stainless steel brushed finish.
 2. PDI Sonicbar brand SH-460 half-mortise or SH-461 surface bolted high strength cast 6-way adjustable hinges. Hinges shall be capable of smooth operation and designed so one (1) hinge will carry entire door weight. Hinges shall be manufactured of structural quality steel and contain a stress proof pin, steel pintle, steel straps and a spherical bearing. Adjust hinges with an allen wrench. The exposed surfaces shall be factory USP prime finish.
- J. Weatherstripping, Sill Wiper Seal and Threshold Arrangement (*optional*):
 1. Exterior doors shall be sealed with PDI Model H-280W-SS heavy duty weatherstripping. Fully adjustable SS stainless steel retainers containing closed cell neoprene rubber are fabricated to door size. PDI Model H-220 adjustable astragal with USP prime finish shall be attached to and swing with the inactive leaf of pair at meeting style.
 2. PDI Model H-344 sill wiper seal shall be field attached to interior door bottom and compress against PDI's 'half-oval' steel threshold or PDI recommended commercial threshold meeting site conditions.

3.3 Finish

- A. All tool marks and imperfections shall be removed and exposed welding joints dressed smooth. Surfaces shall be cleaned and if required, sand blasted for maximum paint adhesion. Exposed surfaces shall be factory prime painted with manufacturer's standard rust inhibitive metal primer.

3.4 Recommended Manufacturer

- A. Protective Door Industries (PDI), Harvey, IL 60426; www.protectivedoor.com; 708/225-3539; sales@protectivedoor.com.
- B. Approved equal.

PART 4 – EXECUTION

4.1 Packing and Shipping

- A. Each door and frame shall be marked with the Architectural door number.
- B. Material shall be securely attached to pallets for shipping. Door vendor shall determine best manner to organize and arrange material. Packing list shall be included with shipment.
- C. Upon receipt of materials and prior to installation, store all materials in a dry, protected interior location to prevent damage.

4.2 Installation

- A. Installation shall be in strict accordance with the approved 'as built' installation drawings and data sheets provided by door vendor at time of submittal. Frames and embeds shall be installed plumb, level, square and rigid. Doors shall be securely hung in place and adjusted for proper operation and ease of swing. The mortise hardware components are factory installed with the trim attached at job-site. All latch bolts shall fully extend into strike cut-outs. Field operational test shall be performed by Contractor's personnel or owner's representative after completion of installation.
- B. Door assembly shall be finish painted as applicable under another referenced section.